



SHOE 5.0

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Study On Industry 5.0 Applied To The Footwear Industry In Europe

Partnership for Footwear Industry 5.0 Readiness

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1. What is i5.0?

Industrial Revolutions throughout history have pushed toward progress and marked our entire society. These Industrial Revolutions conveyed significant advancements in transportation, communication, and manufacturing, as well as a shift from manual labour to machine-based production and the rise of the factory system.

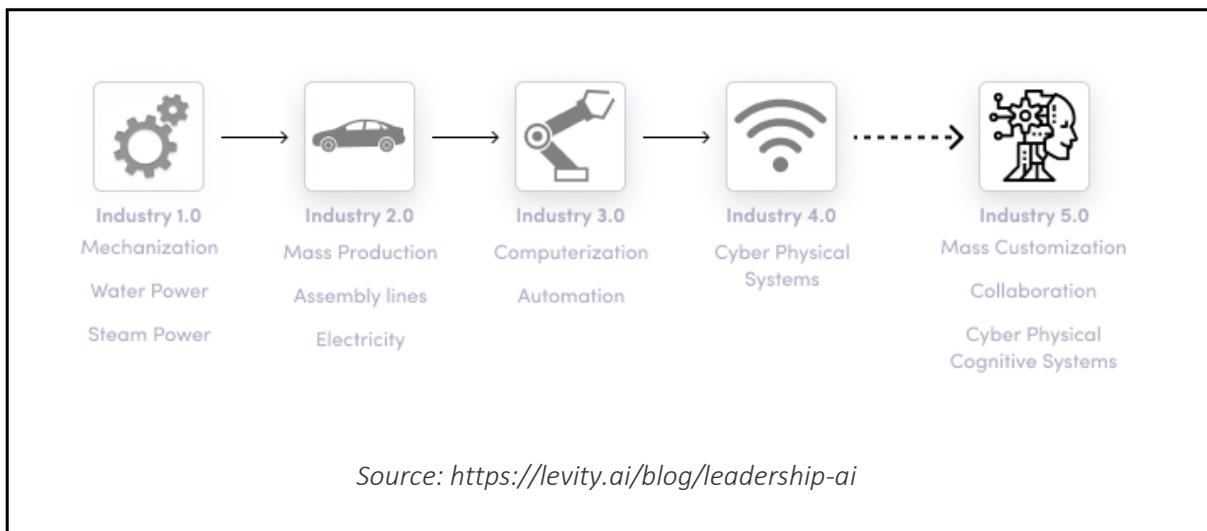
In short, historically, several key industrial revolutions occurred, including:

- The First Industrial Revolution (1760-1840) was characterised by the development of new technologies and manufacturing methods, such as the steam engine and the multi-spindle spinning machine, which led to increased productivity and economic growth.
- The Second Industrial Revolution (1870-1914) witnessed the advent of new forms of energy, such as electricity and oil, as well as the emergence of new technologies. For example, the internal combustion engine led to the mass production and the growth of new industries, such as the steel and chemical industries.
- The Third Industrial Revolution (1969-present) is characterised by the rise of computerisation and automation, which has led to increased productivity and efficiency in manufacturing and other industries.
- The Fourth Industrial Revolution is known as Industry 4.0 (2010-present). It is marked by the emergence of new technologies such as Artificial Intelligence, Robotics, the Internet of things, 3D Printing, block-chain, and quantum computing. In addition, it is expected to bring even more significant changes to how we live and work by integrating the "smart factory" concept, where machines and systems can communicate and make decisions autonomously.
- Nowadays, Industry 5.0 is the natural evolution of Industry 4.0. In January 2021, the European Commission published a report entitled Industry 5.0 - Towards a sustainable, human-centric, and resilient European industry. The pillars on which Industry 4.0 is based aim at Digitalisation and Artificial Intelligence to increase production flexibility and efficiency. Instead, Industry 5.0 adds social equity and sustainability to the above, emphasising humanity, the long-term progress of society, conservation, and rational exploitation of the planet's resources.

Although these technological and industrial revolutions are crucial in our advancement as a society and civilisation, there are drawbacks worth mentioning, especially since the main forces guiding the steps forward have previously been profit and growth, often at any human and environmental cost.

In the footwear industry, the industrial revolutions have led to significant advancements in the production and materials for footwear, making shoes more affordable, diverse in design and technologically advanced. However, from the human viewpoint, the work in the factory has always been highly manual, with repetitive tasks and tedious operations. This is because the footwear manufacturing system is based on complex geometries and is notoriously difficult to automate, leaving it at its core a human-operated system [1]. Therefore, having workers perform monotonous and routine tasks is similar to denying them the opportunity to develop more motivating skills and, in time, can lead to operational mistakes and professional dissatisfaction.

Considering this point, it is possible to understand why some people have felt that the footwear industry is falling behind in technological advancements compared to other industries and why finding highly skilled employees can be challenging. It brings us to a unique historical moment, where Europe is driven by a transformative vision to step towards Industry 5.0, which is foreseen to change footwear manufacturing on a more impactful scale than before [2].



As it was defined in previous works, "Industry 5.0 is first an industrial evolution led by humans based on the 6R (Recognise, Reconsider, Realise, Reduce, Reuse and Recycle) principles of industrial upcycling, a systematic waste prevention technique and logistics efficiency design to add value to living standards, innovative creations and produce high-quality custom products" [3], [4].

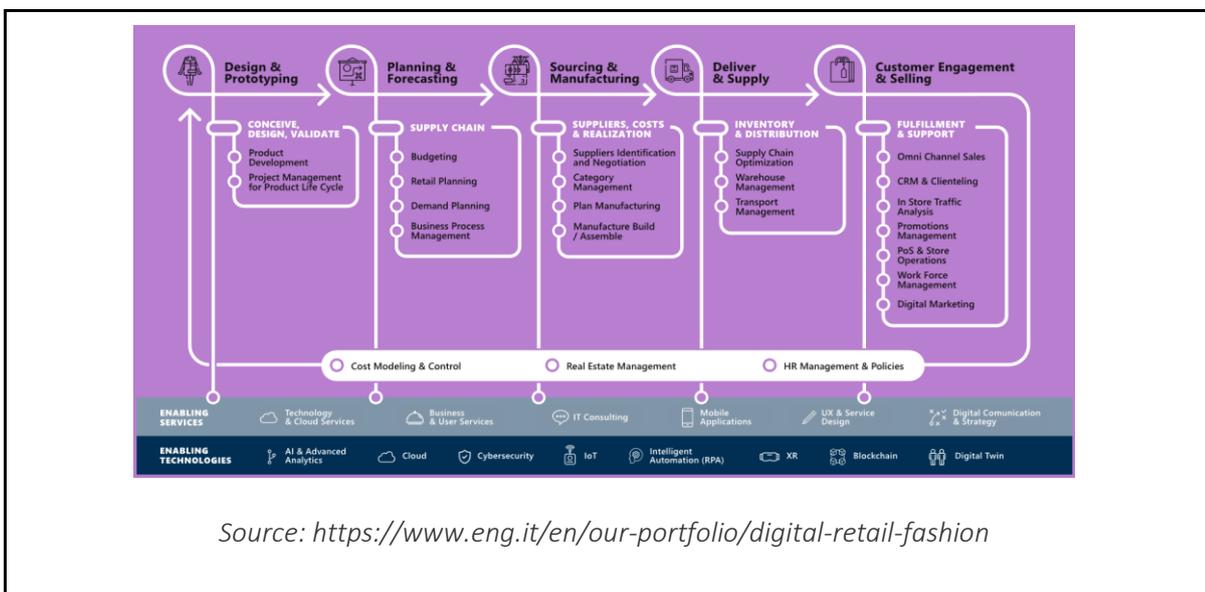
The main difference between Industry 4.0 and Industry 5.0 is that Industry 4.0 is mainly focused on integrating technology into manufacturing, while Industry 5.0 emphasises the integration of technology into the entire value chain and the creation of new business models with increased human participation. Industry 5.0 aims to create a more connected and sustainable industrial ecosystem where the physical and digital worlds merge to create new opportunities for growth and innovation [3].

Thus industry 5.0 is expected to have a significant influence on the footwear industry, and some potential impacts expand to the following directions:

- Increased customisation and personalisation of products due to advanced technologies such as 3D printing and computer-aided design. Manufacturers will be able to create highly customised and personalised footwear for individual customers and specific needs[5].

- Greater sustainability and eco-friendly impact brought by the emphasis on sustainability in Industry 5.0. This direction aims to drive the use and development of more eco-friendly materials, such as plant-based leather and recycled materials[6]–[8].
- Improved efficiency and process automation in footwear manufacturing thanks to the integration of technologies such as robots, cobots and the Internet of Things, which in turn is expected to lead to more significant cost savings and faster production times [1], [9], [10].
- Industry 5.0's focus on connectivity and technology integration into the entire value chain may lead to the creation of new business models in the footwear industry, such as subscription-based or rental models [11], [12].
- Smart and connected shoes are also feasible. Industry 5.0 technologies may also lead to the development of smart and connected shoes that can track fitness and performance data and provide feedback to users [13].

Overall, Industry 5.0 is expected to bring fresh innovation and efficiency in the footwear industry, leading to more sustainable and personalised products, new business models and improved performance tracking capabilities [14].



In other words, at its heart, Industry 5.0 shifts from a focus on economic profit and growth without regard to a focus on societal value, and at the same time, it represents a shift in viewpoints from welfare to wellbeing [15].

1.1 The origins of i5.0

Building on the foundations of the industry 4.0 (i4.0), the fourth industrial revolution much more focused on technologies, industry 5.0 (i5.0) is being setup as the fifth industrial revolution, focused on the humans and how they interact with the technologies. It is supported 3 main pillars [16], [17]:

- Sustainability
- Resilience
- Human-centrism

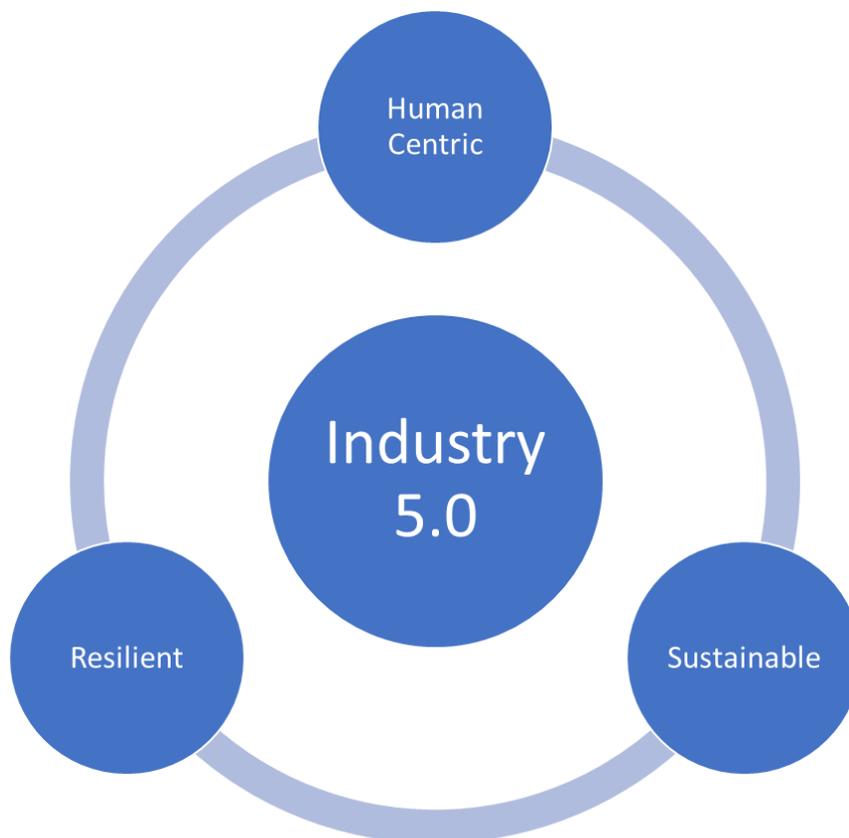


Figure 1: Industry 5.0 main pillars

The term "Industry 5.0" was coined at the beginning of 2021 by the European Commission with the aim of refocusing the development of the sector towards a production model that uses technology to be more competitive, but also to generate a positive impact on society. In this sense, Industry 5.0 does not come to replace Industry 4.0, but appears to complement the progress brought by the different technologies and to enhance the positive relationship between man and machine.

While i4.0 was focused on the enabling technologies, such as robotics, internet of things, augmented reality, or even additive manufacturing, i5.0 aims to put those technologies servicing the human workers.

Industry 5.0 brings a change in the economical and societal paradigms with strong parallels with Society 5.0 presented in Japan [18].

Society 5.0 aims for a human-centred society with an equilibrium between the economics and social realms. This will be based on a deep interaction between cyberspace and physical space.

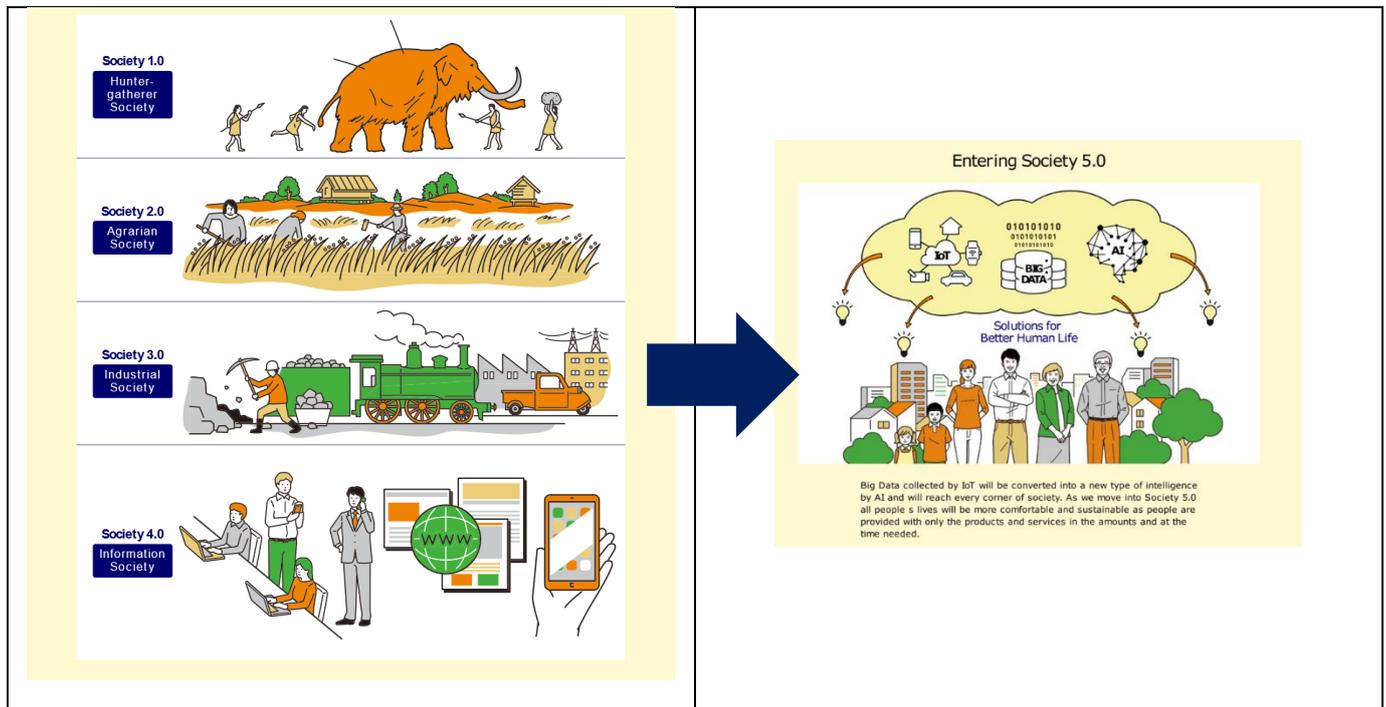


Figure 2: Source CAO, Japan [18]

Parallels and differences can be traced between i4.0 and Society 5.0 where it can be seen that i4.0 lacked the approach to the human factor, where society 5.0 is focused Table 1.

Table 1: Industrie 4.0 vs. Society 5.0 as in [19]

Title	Industrie 4.0 (Germany)	Society 5.0 (Japan)
Design	High-Tech Strategy 2020 Action Plan for Germany (BMBF. 2011) Recommendations for implementing the strategic initiative INDUSTRIE 4.0 (Industrie 4.0 Working Group, 2013)	5th Science and Technology Basic Plan (released 2016) •Comprehensive Strategy on Science, Technology and Innovation for 2017 (released 2017)

Objectives, Scope	Smart factories Focuses on manufacturing	Super-smart society Society as a whole
Key phrases	Cyber-physical systems (CPS) Internet of Things (IOT) Mass customization	High-level convergence of cyberspace and physical space Balancing economic development with reso- lution of social issues Human-centered society

Industry 5.0 is being built on the path taken by i4.0, no supressing it, but as a natural evolution.

“(...) Industry 5.0 should not be understood as a replacement nor an alternative to, but an evolution and logical continuation of the existing Industry 4.0 paradigm. As such, the concept of Industry 5.0 is not based on technologies, but is centred around values, such as human-centricity, ecological or social benefits.” [20]

1.1.1 Enabling technologies

The European Commission elected a few enabling technologies identifying at the same time the challenges they present [20].

Enabling technologies

- Human-centric solutions and human-machine-interaction technologies that interconnect and combine the strengths of humans and machines.
- Bio-inspired technologies and smart materials that allow materials with embedded sensors and enhanced features while being recyclable.
- Real time-based digital twins and simulation to model entire systems.
- Cyber safe data transmission, storage, and analysis technologies that can handle data and system interoperability.
- Artificial Intelligence e.g., to detect causalities in complex, dynamic systems, leading to actionable intelligence.
- Technologies for energy efficiency and trustworthy autonomy as the above-named technologies will require large amounts of energy.

Challenges

- Social dimension.
- Governmental and pollical dimension.
- Interdisciplinarity and transdisciplinary.

- Economic dimension.
- Scalability.

Human-centric

Human-centric solutions and human-machine-interaction technologies that interconnect and combine the strengths of humans and machines.

- Multi-lingual speech and gesture recognition and human intention prediction.
- Tracking technologies for mental and physical strain and stress of employees.
- Robotics: Collaborative robots ('cobots'), which work together with humans and assist humans
- Augmented, virtual or mixed reality technologies, especially for training and inclusiveness.
- Enhancing physical human capabilities: Exoskeletons, bio-inspired working gear and safety equipment.
- Enhancing cognitive human capabilities: Technologies for matching the strengths of Artificial Intelligence and the human brain (e.g., combining creativity with analytical skills), decision support systems.

Bio-inspired technologies

Bio-inspired technologies and smart materials that allow materials with embedded sensors and enhanced features while being recyclable.

- Self-healing or self-repairing.
- Lightweight.
- Recyclable.
- Raw material generation from waste.
- Integration of living materials.
- Embedded sensor technologies and biosensors.
- Adaptive/responsive ergonomics and surface properties.
- Materials with intrinsic traceability.

Real time-based digital twins and simulation

Real time-based digital twins and simulation to model entire systems.

- Digital twins of products and processes.
- Virtual simulation and testing of products and processes (e.g., for human-centricity, working and operational safety).
- Multi-scale dynamic modelling and simulation.
- Simulation and measurement of environmental and social impact.
- Cyber-physical systems and digital twins of entire systems.
- Planned maintenance.

Cyber safe

Cyber safe data transmission, storage, and analysis technologies that are able to handle data and system interoperability.

- Networked sensors
- Data and system interoperability
- Scalable, multi-level cyber security
- Cyber security/safe cloud IT-infrastructure
- Big data management
- Traceability (e.g., data origin and fulfilment of specifications)
- Data processing for learning processes
- Edge computing

Artificial intelligence

Artificial Intelligence e.g., to detect causalities in complex, dynamic systems, leading to actionable intelligence.

- Causality-based and not only correlation-based artificial intelligence
- Show relations and network effects outside of correlations.
- Ability to respond to new or unexpected conditions without human support.
- Swarm intelligence
- Brain-machine interfaces
- Individual, person-centric Artificial Intelligence
- Informed deep learning (expert knowledge combined with Artificial Intelligence)
- Skill matching of humans and tasks
- Secure and energy-efficient Artificial Intelligence
- Ability to handle and find correlations among complex, interrelated data of different origin and scales in dynamic systems within a system of systems.

Energy efficiency and trustworthy autonomy

Technologies for energy efficiency and trustworthy autonomy as the above-named technologies will require large amounts of energy.

- Integration of renewable energy sources
- Support of Hydrogen and Power-to-X technologies
- Smart dust and energy-autonomous sensors
- Low energy data transmission and data analysis

This document will present and discuss the most relevant technologies for the footwear industry, the market opportunities that arise from i5.0 and what are the challenges and opportunities for training and education resulting from the key changes that i5.0 brings.

1.2 National Policies for i5.0

1.2.1 Portugal

In **January 2014**, the European Commission launched the communication entitled “**For a European industrial Renaissance**”, marking the introduction on the **European Agenda of Reindustrialization**, as part of the recovery strategy after the financial crisis of 2008-09.

In **June 2014**, Jean-Claude Juncker becomes the new President of the Commission, with the big promise of “re-industrialization of Europe” and an investment plan known as “**Juncker’s Plan**”, targeting 500.000 M€ of public and private investment by the **end of 2020**.

In **2015**, the UN launched the **17 Sustainable Development Goals (SDGs)** that marked the Agenda 2030.

In **December 2019**, the new European Commission, led by Ursula von der Leyen, presented the **European Green Deal**, which is the main priority of the new European Agenda the EU 's new growth strategy towards climate neutrality in 2050, inserting itself at response to the mentioned UN SDGs. It is along the lines of the new Green Deal that will be sketched the multi-annual 2021-2027 European financial framework.

In **March 2020**, as part of the European Green Deal strategy, the Commission presented the communication “**A New Industrial Strategy for Europe**”, which foresees a new model of governance for the transition to climate change neutrality and digital leadership, with Europeans’ industrial ecosystems who approach the main players of each value chain: Academy, Research, Suppliers, SMEs, Large Companies, Public Authorities.

The new European Industrial Strategy has in mind a world leader industry (i) Green and Circular; (ii) Digital and (iii) Competitive. Within the new model the industrial sectors are encouraged to define their own roadmaps toward climate neutrality and digitalization, supported by:

- high research and development of quality skills with the support from the EU, in a logic public-private partnership to help the industry to develop the necessary technologies to achieve these goals.
- upskilling and reskilling for adaptation to the new technologies (such as digitalization, automation, and artificial intelligence).
- adaptation of education and training.
- lifelong learning.
- the necessary investment, including critical infrastructures.

Since there are no national policies guiding the implementation of industry 5.0 assumptions, these are the guidelines inspiring the transition to a sustainable, human-centric, and resilient industry in Portugal.

PT i5.0 starts then from an industrial production concept that must be sufficiently broad, encompassing the incorporation of support services to industrial activity, with added value, which includes innovation and technology, namely digital technologies, as well as the design and other competitiveness factors.

Some studies and position paper were draft upon these guides such as:

AEP studies and positions papers

Portugal Industrial 5.0 - PT i5.0 – Program Strategy for the Enhancement of Portuguese Industry[21]

Considering that reindustrialization of the country is the way right towards innovation, improving productivity and competitiveness and growth economic sustainable, and considering it fundamental to place the theme in its two aspects – return of industries relocated and development of new industries more intensive in knowledge and/ or capital – on the national agenda , the AEP - Associação Empresarial de Portugal proposes Portugal Industrial 5.0 – PT i 5.0 – Program Strategy for the Enhancement of Portuguese Industry.

The Program has the focus in tradable goods and services, boosting the increase in exports, reinforcing and diversify production and supply, according to the objective of withdrawing the country from dependence on other supply markets, namely outside Europe, and relaunch the economy at the post-pandemic phase.

In designing Portugal Industrial 5.0, AEP looked to the experience successful implementation of previous funding Programs, adapting its essence to the current and future challenges, having defined five dimensions, all they oriented towards industrial activity:

- Technological Training (Innovation, R&DT).
- Training for Skills (Training and Requalification).
- Training Business for Efficiency (Productivity, Competitiveness, Internationalization, Commercialization and Marketing).
- Training for Capitalization and Diversification of Sources.
- Training of Industry Support Associations' Entities

COMPETE

The COMPETE publication refers to the EC publication of 4th January 2021. “Industry 5.0 – Towards a sustainable, human - centered and resilient European industry” [22]

Industry 5.0 complements the existing Industry 4.0 paradigm, highlighting the research and innovation as engines of a transition to a sustainable, human - centered and resilient European industry. Industry 5.0 tries to join the value of new technologies, providing prosperity in addition to jobs and growth, while respecting the limits of the planet and placing the worker 's well-being at the centre of the production process.

Industry 5.0 needs continually innovating to staying competitive. Now, more than ever, it is necessary to invest in the future, to overcome economic challenges imposed by the coronavirus pandemic, and establish a "new normal" with a more competitive, more sustainable, and greener Europe.

1.2.2 Romania

There is no information on any specific national strategies in Romania regarding Industry 5.0. However, Romania has been developing its Industry 4.0 strategy, which aims to support the digital transformation of the manufacturing sector through the adoption of advanced technologies such as automation, robotics, artificial intelligence, and the Internet of Things [23].

The Romanian government has identified the development of the manufacturing industry as a priority area for economic growth and has launched some initiatives to support this goal. For example, the North-East Regional Development Agency has established a RIS3 - Research and Innovation Strategy for Smart Specialisation of the North-East Region (Gheorghe Asachi technical University of Iasi is part of North-East Region). RIS3 North-East 2021-2027 was developed in a broad regional partnership with relevant stakeholders from academia, research institutes, business, local public administration, and civil society using the entrepreneurial discovery mechanism. The aim of this strategy is to establish the areas where investments under Policy Objective 1 of the Cohesion Policy "A more competitive and intelligent Europe" will be focused, i.e., meeting the enabling condition for the allocation of ERDF under the Regional Operational Programme 2021-2027. The main points are as follows:

- Focus on regional strengths: The strategy aims to identify and exploit the unique strengths and opportunities of the North-East Region in Romania. The strategy focuses on six key areas of specialization: agro-food, health and wellness, energy, creative industries, IT, and advanced manufacturing.
- Promote innovation: The strategy aims to support the development of a knowledge-based economy in the region by promoting innovation and the adoption of new technologies. The strategy includes measures such as funding for research and innovation projects, support for business incubators and accelerators, and the promotion of international cooperation and collaboration.
- Support entrepreneurship: The strategy aims to foster a culture of entrepreneurship and innovation in the region by providing support and resources to start-ups and small and medium-sized enterprises. This includes measures such as access to funding, mentoring, and coaching, and business development support.

- Strengthen regional cooperation: The strategy aims to strengthen the capacity of regional actors to innovate and to promote collaboration and cooperation among regional stakeholders. This includes measures such as the development of innovation networks, the promotion of cross-sectoral collaboration, and the establishment of partnerships with other regions and countries.
- Promote sustainable development: The strategy aims to promote sustainable development in the North-East Region by supporting the development of green technologies and the adoption of sustainable practices in industry and agriculture. The strategy also includes measures to promote social inclusion and to support the development of rural areas.

Overall, while Romania has not yet developed a specific strategy for Industry 5.0, the country is committed to promoting the digital transformation of its manufacturing industry and supporting innovation and entrepreneurship more broadly.

1.2.3. Italy

There is no information on any specific national strategies in Italy regarding Industry 5.0. Italy fully adopts the European strategy.

1.2.4. Spain

There is no information on any specific national strategies in Spain regarding Industry 5.0. Spain fully adopts the European strategy.

2. Key changes

2.1 Framing

The world is facing major changes. The trend of digital transformation cannot be halted, and this is causing profound changes in society in a wide range of spheres, including in the professional and personal lives of individuals.

Society can follow many directions in the face of this reality. While the massive application of day-to-day technology offers numerous advantages, such as higher living standards and greater convenience, technological development can also harm society in terms of its employment consequences, social inequalities that can amplify the unequal distribution of wealth, interpersonal relationships, and security.

Faced with this crossroads, the performance below the expectations of Industry 4.0 and the environmental, energy and demographic challenges (aging population and consequent declining workforce), a new philosophy emerges: The Society 5.0.

Society 5.0 proposes “A human-centric society that balances economic progress with the resolution of social problems through a system that effectively integrates cyberspace and physical space,” statements from the Office of the Government of Japan [24].

Industry 5.0, resulting from the incorporation by the European Commission of the revolutionary perspective of Society 5.0 into European industry, is assumed as a new paradigm of development.

Industry 5.0, which puts the well-being of employees as a priority and aims to use new technologies to transcend technical and economic objectives while respecting the production limits of the planet, is based on three key aspects:

- Centralization in the Human Being
- Sustainability
- Resilience

Within the framework of **Human Centralization**, with Industry 5.0 the interests, needs and capabilities of the human being replace technology in the role it assumed as the starting point and centre of the production process. In this new paradigm, instead of questioning what one can do with a certain technology, one wonders what it can do for people and how technology can promote talent, diversity, and empowerment.

To respect planetary boundaries, Industry 5.0 aims to lead actions on **sustainability**. This new paradigm aims to develop circular production processes that reduce, reuse, and recycle natural resources to avoid their degradation and exhaustion so that the satisfaction of current needs is ensured without compromising the ability of future generations to meet their own needs.

Resilience in the light of Industry 5.0 refers to the robustness of industries to external factors. Geopolitical changes, environmental disasters, and health crises, such as the Covid-19 Pandemic, the Russia-Ukraine armed conflict, among others, highlight the fragility of the European approach to global production. Given this, it is necessary to implement mechanisms that confer immunity, flexibility, resilience, and responsiveness to European Industry.

Several publications show their views about these topics [24]–[39], a compilation of their views and how they apply to the project and the key changes needed for i5.0 is present bellow.

2.2 Centralization in the Human Being

At a time when technologies are increasingly advanced, intelligent, and become more effective and autonomous, it is necessary to turn attention to the human being and the role that it can and must play in the production process to minimize the impacts that digitalization is having on unemployment levels, skilled labor, increased average life expectancy, decreased birth and employee well-being.

When compared to Industry 4.0, one of the most important paradigmatic transitions that characterize Industry 5.0 is the shift of focus from technological progress to a fully human-centered approach. With the implementation of this new paradigm, we seek to promote a much more balanced relationship between technology and the human being, we intend to realize the dream of having men and machines working in perfect symbiosis.

2.2.1 Changing the Role of the Employee:

In Industry 5.0, the role and narrative around employee role in organizations change substantially. If previously a worker was perceived as a cost, a financial burden for the company, Industry 5.0, assumes the investment status that will create value for the organization.

This change in employee understanding implies that employers are interested in investing in the skills, skills, and well-being of their workers to achieve their objectives and provide the worker with pleasure and well-being.

This approach implies more than a balance in the cost-benefit ratio: human capital becomes truly valued and appreciated. The worker is more empowered, and the working environment is more inclusive. To achieve this, workers must be closely involved in the design and deployment of new industrial technologies, including robotics and AI.

Workers are given more influence and, consequently, greater responsibility in the formation of the production process through virtual means.

From this point of view, issues related to:

- ✓ Hourly flexibility.
- ✓ Flexibility of working modalities.

- ✓ Autonomy.
- ✓ Career progression.
- ✓ Benefits and incentives.
- ✓ Elasticity of hierarchical structures,

They are thought in the perspective of satisfying and retaining the employee.

For this purpose, companies should create forums for discussion to understand what truly satisfies employees, what their needs, dreams and ambitions at a personal and functional level, the functions they enjoy and want to perform, the skills they possess and the consequent most valuable they can bring to the organization's activity, their greatest difficulties, fears, and fears, among others.

This auscultation can be done in numerous ways:

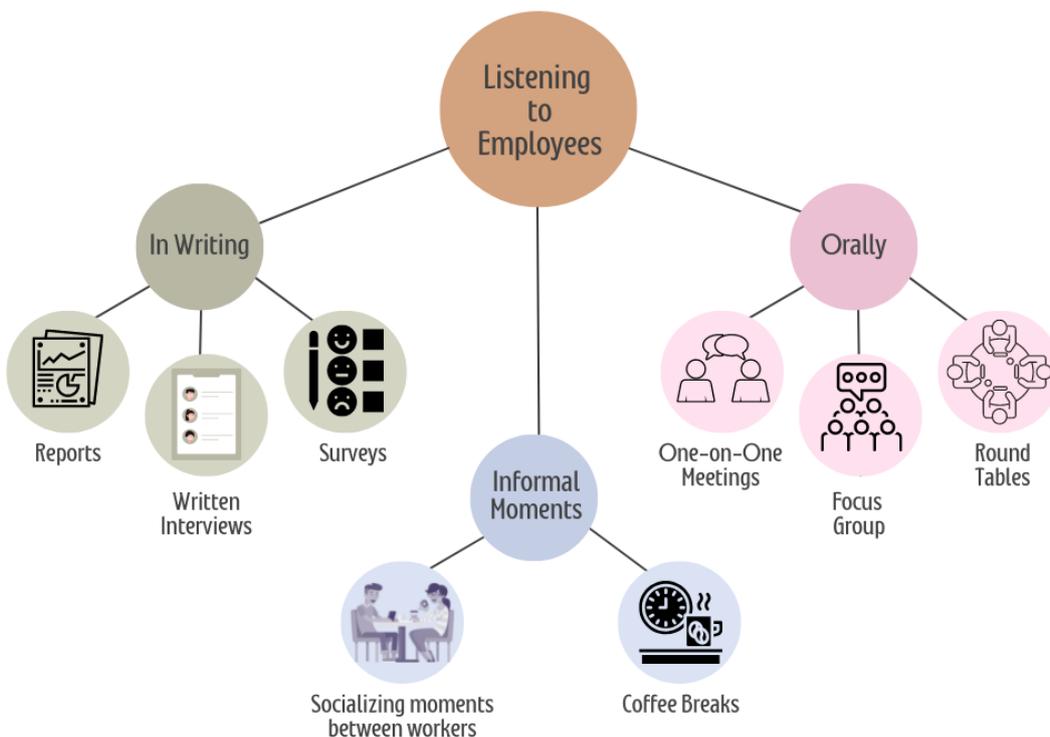


Figure 3: Listening to Employees

Although it consumes much time resources and eventually, at a later stage, finances (in the application of concrete measures), this proactive position of People Management is necessary, not only because it is a presupposition of Industry 5.0, but due to the growing global denunciations of the existence of specialized talent gaps in the labour market, where the retention of employees (who fit functionally and personally in the profile of the intended candidate) is the slogan.

2.2.2 Link Worker-Technology:



In their liaison with workers, for Industry 5.0, technologies aim to serve people. In this perspective, technologies are adapted to the needs, talents and diversity of workers, rather than being people who have shaped themselves into machines. The goal is to expand the worker's capabilities with innovative technological means, rather than replacing the worker with robots.

This rupture of work methodology is due to the numerous reports of inadequacy and lack of technological knowledge on the part of a workforce that is very aged, poorly qualified and prepared for the technological revolution, which ends up calling into question the evolution of the business by not being able to adapt to the technological investments made by companies.

To fill this reality, given that the interaction between the worker and technology will be increasingly intense and unavoidable, there are several approaches, which in addition to being widely practiced, present very satisfactory results:

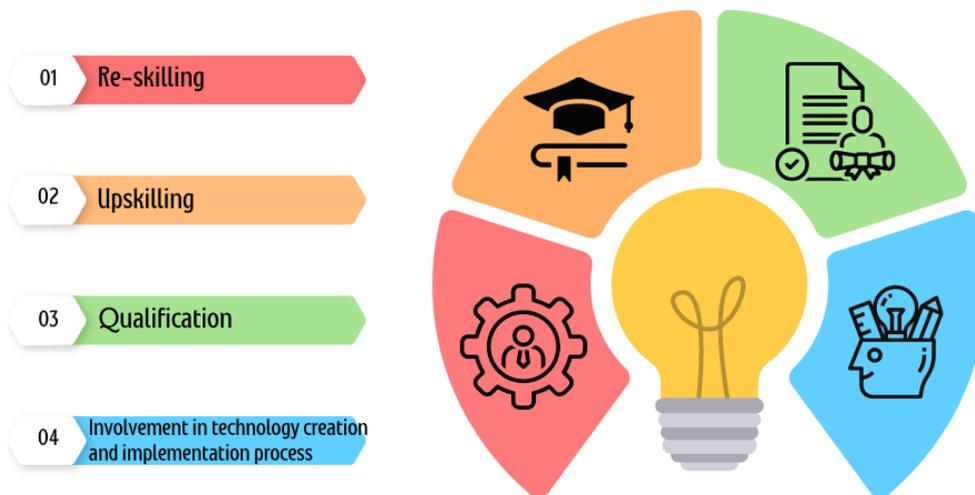


Figure 4: Requalification, Upskilling, Qualifying and Engagement in the process of creation and implementation.

Given that, for the fullness of this paradigm, it presupposes the existence of a diverse and complete workforce at the technical and behavioural levels, more inclusive workplaces and more skilled workers are needed. Organizations must invest in highly specialized qualification sessions in the technology held. This investment of the company, which highlights the centralization of the employee, will offer, in addition to productive return, benefits to the level of employee satisfaction and consequently commitment and retention.

Another viable option to strengthen the ties between the human being and the technology is the involvement of the collaborator in the process of designing the technology. Although this practice is not of transversal application to all workers or all branches of activity, because it requires greater and more in-depth technological knowledge, involving employees in the process of creating a certain technology will allow a product much more personalized and adapted to reality. It will also reduce costs when training other workers and reduce delivery waiting times, while providing satisfaction to the involved employee who will feel more valued, with greater knowledge of the process and greater capacity to execute new procedures.

In the context of the challenges posed by this “worker-technology” relationship, the most difficult factor in this symbiosis comes from the aging workforce. Tendingly less qualified and more resistant to change and technology, age groups from the age of 50 can become barriers to the introduction of Industry 5.0 in companies at their fullest.

In these cases, companies must invest and devote more time to these employees to explain to them what technology does, how it does are, what the benefits of its use, what the role of the employee with the machine is, and how it should handle it. This more personalized treatment, in addition to highlighting once again the centralization in the human being, will help to break down barriers with technology, since the resistance to it by the more mature generation comes, for the most part, from fears and prejudices, ignorance, tiredness, conformism and alienation to reality.

2.2.3 Re-skilling, Up-skilling, and Skills:

The skills dimension is another important set of considerations for Industry 5.0.

Skills needs are evolving as rapidly as technologies. European industries are fighting skills shortages and education, and training institutions are unable to meet this demand. This applies both at an expert level and to general digital skills requirements. On the supply side, young people do not feel adequately equipped with the skills needed for the future labour market. A study by Deloitte found that 70 % of young people believe they have only some of the skills that will be needed to succeed in the work of the future.

With all the digitization and automation of processes and robots taking on labour-intensive tasks, European industry struggling with the lack of human resources and talent, and education and training institutions being unable to meet this demand.

Reskilling, Upskilling and Qualification are dimensions, within the framework of human centralization, very relevant to Industry 5.0.

Requalification is the process of acquiring new skills that allow the development of new functions or different scopes of action within what are the normal functions of employees. Within companies, using qualification sessions to equip employees with new skills is relevant when they are intended to take on different functions or perform their tasks differently. In an ever-evolving labor market, where the emergence and extinction of functions is a reality, job requalification is an urgency and a responsibility to be assumed by companies.

This job requalification can be achieved by using internal training, where employees with more experience take on the role of internal trainers and transmit their knowledge about the subjects given to colleagues, or external training using certified training entities.

Training, particularly in-house training, should not be taught in the conventional form, “classroom model”, because it is an obsolete and ineffective format. Internal training actions should therefore be carried out when performing duties, for example in the mentoring format.

In turn, Upskilling is meant to deepen, improve, and update skills and knowledge previously acquired, on a continuously, thus increasing the employee their mastery of a particular subject. Within companies, boosting employee upskilling happens when organizations want them to take higher hierarchical positions, have more responsibilities, be more effective and present higher quality in their roles. This Upskilling will allow greater specialization in each subject and thus address the lack of training of employees, namely middle staff.

Re-skilling and up-skilling are not only exhausted in the list of technical skills, hard skills (artificial intelligence, automation, among others), but these processes also give great emphasis to soft skills (flexibility, communication, interpersonal relationships, teamwork, management of people), increasingly relevant and requested by employers.

This investment of companies in the upskilling and upskilling of employees, in the perspective of centralization in the human being, will allow it to be more valuable to the organization and more employable in the

future, while for companies favours the retention of talents and skilled workforce will allow them to meet the demands of the market more easily.

Never forget that these tools need a diagnosis of prior needs to be fully personalized, adequate, effective and realistic, as well as follow-up and subsequent impact assessment, to avoid the use of resources in vain in the future.

However, upskilling and upskilling by companies are not the only method for the qualification of the workforce.

Given the current situation of incapacity of education and training institutions to train young people for the current labour market, it is important to study and analyses the feasibility of developing and incorporating new training themes into national qualification catalogues.

Preparing future workers to deal with technical issues of automation, digitalization, artificial intelligence, and cyber physics, among others, without neglecting the transversal skills of interpersonal relationship, emotional intelligence, problem-solving, communication, teamwork, emotion management, critical spirit and cognitive flexibility should be the stakes of future training plans.

Adapting education for the training and development of industry-oriented skills and skills, despite being a demanding challenge given the high volatility of the market, is an added value for both organizations and future employees. Organizations address the difficulties experienced in terms of quality, subsequently succeeding in raising productivity levels, and young people, besides being able to integrate more easily into the labour market, do not feel so difficult to adapt to a reality that is more attractive and challenging, by focusing on digital skills and understanding how Artificial Intelligence (AI) works.

This requires a large involvement of public and private bodies in identifying what training needs the market reveals, through close and constant contact with companies. After diagnosis, it is necessary to develop interactive and dynamic training plans and incorporate them into national and European qualification plans.

Finally, since the new paradigm foresees the adaptation of technology to the human being, and that qualification, requalification and upskilling may not be 100 % effective, an innovative approach to technological development is essential. Since Industry 5.0 focuses on artificial intelligence, augmented reality and collaborative robots, it is necessary to demystify these instruments and turn them into more intuitive, user-friendly tools. It is important to adapt these mechanisms to less qualified and less knowledgeable generations in the technological world.

All the points underlined, where the common denominator is the focus on the human being, will promote the talent and empowerment of the worker, causing in it a feeling of well-being, belonging and happiness, culminating in the retention of the employee. This, however, offers a huge challenge for Human Resource Management, which in addition to managing employees who are in a much more advantageous and privileged position, must manage mixed teams, also composed of robots. Managing this diversity will require a lot of mental elasticity and critical spirit.

TO achieve this presupposition, it is necessary for legislation at A Community level and in each country to strengthen workers' rights, regulate labour relations between robots and humans, have flexible work models, while at the same time setting limits to interference in personal life, among others. It is then necessary that labour laws begin to reflect what are the realities and challenges of a constantly and rapidly evolving working world.

In addition, it is necessary to provide financial support to companies so that they can implement the stated assumptions since they involve large investments and companies often lack the working capital necessary for the implementation of the policies.

In short, Industry 5.0 presupposes that people become at the centre of business strategies, taking advantage of technologies, which are now designed and implemented to meet their needs. Technology will become a factor of empowerment and integration of human resources which will enable efficient work, and a higher quality of life.

2.2.4 Safe and inclusive work environments

One of the fears associated with the introduction of technology into the world of work is the loss of jobs. Studies show, however, that if applied correctly, technologies can transform spaces and work environments not only safer but more inclusive.

Regarding the safety of workspaces, Eurostat data on this reality show that the sectors where the most accidents at work occur are those where the most dangerous and exhausting tasks could be automated relatively easily and quickly: construction; manufacture; transport and storage [25].

Fatal and non-fatal accidents at work by NACE section, EU, 2020
(% of fatal and non-fatal accidents)

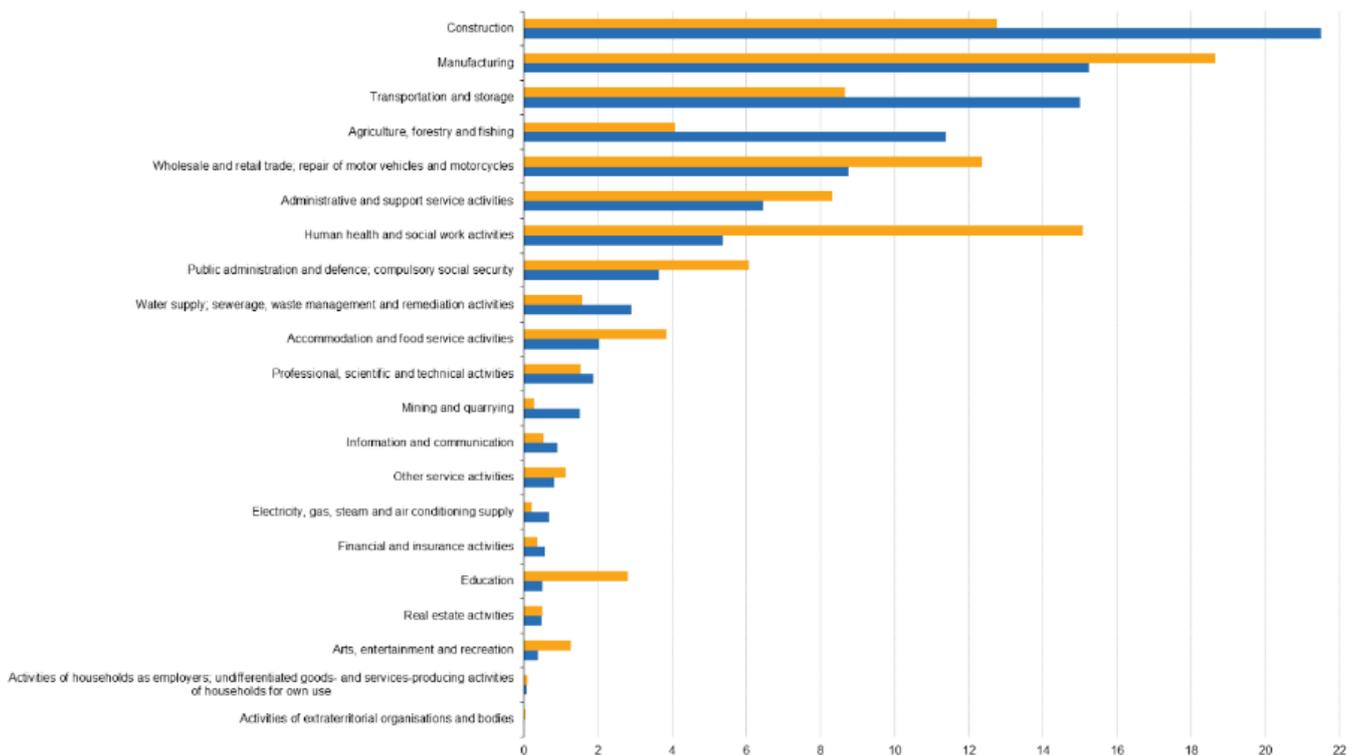


Figure 5: Accidents at Work, EU 2020.

In this context, robots and other machinery can take on a set of repetitive and strenuous tasks that due to the fatigue they cause to employees cause often lethal work accidents.

However, it is not only in this area that technology can serve the worker. The potential of robotic technology when combined and powered by artificial intelligence is infinite.

Artificial intelligence-based technologies, as well as virtual and augmented reality tools, can be used to guide the worker in performing specialized tasks, which would otherwise require expertise and skilled workers. This reality in addition to benefiting the company concerning specialization (and lack thereof) of workers, would also benefit people with less physical and mental capacity who would see their entry into the labour market more facilitated which would in turn revert to a much more inclusive work environment.

A wide range of other opportunities emerges through further digitization of the workforce. The digitalization of industrial processes allows not only remote work but also the entry into the labour market of people living in distant regions and different countries.

Faced with these realities, and the consequences that they entail (burnouts, sedentary lifestyle and posture problems) technology must ensure equal respect and safeguard the well-being and health of employees at

distance work. Digital tools can incorporate, for example, movement alerts, measurement of vital indicators, machinery closure mechanisms, among others.

With the help of new technologies and digital solutions, businesses would foster mental health and a culture of well-being as an integral part of their business culture. This dimension will bring economic benefits to the company due to productivity gains, disease prevention and long-term absences.

2.2.5 The new generations “Y” and “Z”

Although the European industry is currently faced with an aging workforce, it is expected that from 2025, 75 % of this workforce will be made up of the so-called Millennials — Generation Z (born 1981-1996) and Generation Y (born between 1997 and 2012).

These data are of high importance because they will require efforts from companies concerning employee retention.

If Baby Boomers (born between 1946 and 1964) and Generation X (born between 1965 and 1980) are largely work-aficionados, favour teamwork and are multitasking, generations Z and Y prefer flexibility, innovation opportunities, personal and professional life balance, and involvement in a social and environmental project.

Given these motivational factors and the desire and ambition to join companies that reflect their values, companies following the assumptions of Industry 5.0 should contribute to an increasingly less unfair and unequal, healthy, balanced and sustainable world.

In this follow-up, being a socially responsible and environmentally friendly company is not only about adapting production processes, but also creating initiatives outside of essential work activities, such as employee volunteer schemes or organized activities for the community.

2.3 Sustainability

Sustainable development means “development that meets the needs of today’s generations without compromising the ability of future generations to satisfy their own.”

This concept, which aims to reconcile economic development and the protection of social and environmental balances, was first presented in the Brundtland Report 1987 “Our Common Future” of the World Commission on Environment and Development and has since occupied much of the European forums and has been deeply embedded in European policies.

The European Union’s policies in this area are therefore aimed at preserving, protecting and improving the quality of the environment. At the same time, these policies focus on the prudent and rational use of natural resources and contribute to the promotion, at an international level, of measures to address regional or global environmental problems such as climate change and biodiversity loss, including the European Union, the highest standards and the world’s most ambitious climate policies.

In their relationship with industries, the environmental policies emanating from the European Union are designed to accelerate the transition to a sustainable, innovative and circular economy, where biodiversity is protected, valued and restored and environmental-related health risks are minimized.

Of the numerous initiatives and programs with which the European Commission joins or sets up in December 2019, the European Green Deal has adopted the European Green Deal, which clearly outlines what Europe must do to combat climate change and environmental degradation and what steps toward the transition to a sustainable economy as intended with the implementation of Industry 5.0.

To transform the European Union into a modern, competitive and efficient economy, the European Green Deal reinforces the need for resource efficiency, the transition to a clean and circular economy and pollution reduction.

In the context of resource efficiency, companies should: know in detail their production processes, identify the resources used and introduce resource management mechanisms.

First, companies need to know in detail their production process and understand the stages and production cycles that occur between the reception of the raw material and the delivery of the final product to the consumer. It is then important that organizations identify all the resources used during the process described above, both in number and in quantity and costs (human resources, machinery, water, light, fuel, among others). At a later stage, to achieve the fullness of resource efficiency, organizations, based on benchmarking research and feasibility studies, must implement mechanisms for more rational use of these resources.

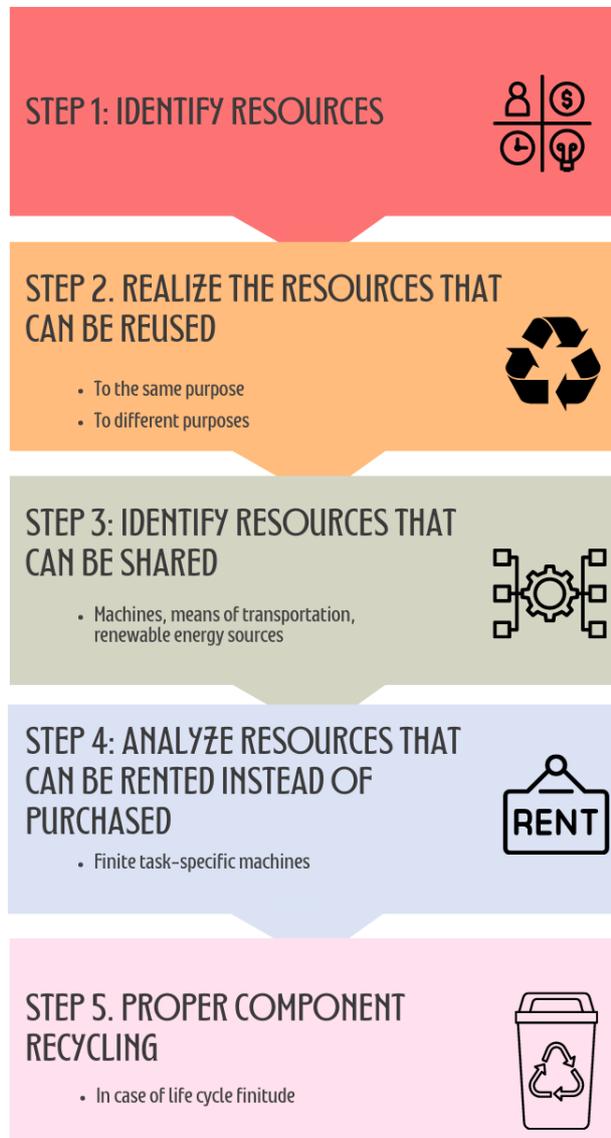
With the increase in industrial production, there was an increase in energy consumption and a consequent increase in carbon emissions. As such, the transition to a clean and circular economy is urgently incompatible with European and international metrics and objectives.

A clean economy means low carbon savings, in other words, economies powered and driven by clean energy, renewable energies such as solar, wind, water, ethanol, biodiesel, biomass energy, among others. In this context, Industry 5.0 foresees smarter production planning, the transition to reusable energy sources and the use of more energy-efficient technologies.

As regards the transition to renewable energy sources, companies should take into account the phenomenon of climate change when choosing alternatives to oil. In the case of southern Europe, for example, the option to select solar energy sources would be advantageous given the scenario of extreme drought that is expected in a near future.

The circular economy is a production and consumption model that involves sharing, renting, reusing, repairing, renovating and recycling existing materials and products as long as possible. The practice of this concept, foreseen by Industry 5.0, within the scope of sustainability, is beneficial for companies because it allows the reduction of costs, a longer life cycle of raw materials, vital in times of scarcity, finitude and increasing demand for raw materials, greater competitiveness, promotion of innovation, among others.

For the implementation of this circular economy, companies should:



On its own, if the efficient use of resources is applied correctly and circular economy procedures are introduced, half of the way to reducing pollution is completed. The rest of the work to be done may be in the most routine situations and less involved with the production process, such as:

- Digitalization of all accounting, administrative and other processes (reduction of paper consumption).
- Development of a system of shared rides and creation of a dining space that avoids massive commuting of employees to eat their meals (decrease of fossil fuel burning).
- Installation of lighting systems by sensors (decreasing electricity consumption).
- Installation of manual hand washing and drying system (decrease of water and paper waste).
- Installation of water fountains and provision of thermal water bottles (decreased consumption of plastics).

Contributing to environmental sustainability should also be researched. In this context, science can contribute to companies by focusing on discovering how they can renew their business model to better account for environmental sustainability at an organizational level in their business ecosystems.

Given the growing environmental and social public concern and the gradual public and state pressure, sustainability is regularly incorporated into business models. The introduction of the sustainability assumptions advocated by Industry 5.0 is numerous: from fast and long-lasting economic benefits to external and internal marketing, attracting and retaining employees and competitiveness, among many others.

This path towards sustainability of industries is not done alone, companies alone do not have sufficient financial sustainability to be at the forefront of technology concerning to renewable energy sources and technologies that are most technologically efficient.

With the European Union aware of this and the context of the business fabrics of its member states, funds have been made available to streamline these processes and minimize the costs inherent in them. Numerous initiatives contribute and finance the acquisition of green technologies, digitization of industries, and research in the area, among others. However, access to these programs should be much more widespread, there should be more money and the application process should be simpler and less bureaucratic.

Industry 5.0, with its pillar on sustainability, gives voice to and supports the only possible model of economic, environmental and social development, the sustainable development model.

2.4 Resilience

Everyday life in a business context is characterized by continuous changes, unforeseen events and setbacks that need to be resolved. The key to dealing with all these obstacles is resilience.

The outbreak of the Covid-19 pandemic, the Russian-Ukraine armed conflict and the drought in Europe are just some of the most recent crises that Europe is struggling with which reflect the urgency of incorporating mechanisms to enable the economy and European industry to be immune to these interferences.

Resilience is understood to be the capacity to resist and respond to external changes, as well as the ability to overcome and adapt to change in the face of current and future challenges associated with it. Resilience also presupposes the growth of the company within adversity and the incorporation of the improvements that arise from the decisions taken at times of concern during the company's activity.

At the industrial level, resilience refers to the need to develop a greater degree of robustness in industrial production, better arming it against disruptions and ensuring that it can provide and support critical infrastructure in times of crisis so that in the face of these moments it does not collapse.

To be more resilient, companies must first acquire the awareness that they are an open system and that they operate in an uncertain and ambiguous, ever-evolving world. The first condition means that companies are not isolated systems and that all changes in the environments around them interfere with their activity (economic crises, political crises, energy crises, among others). Given this reality and the fact that an increasingly demanding world with more and more complex challenges is inserted, companies should seek to develop more proactive and planning management to enable a rapid and appropriate response to possible disruptions.

For more proactive and planning management, companies should identify their greatest vulnerabilities (overdependence on suppliers, few qualified human resources, complex logistics processes, obsolete technology, among others) and work on them, outline contingency plans, so that the impacts of possible failures in these parameters do not jeopardize the production process.

Then, companies, to avoid suffering major negative impacts from the changes operating around them, should seek to predict possible scenarios and identify solutions and paths to follow in each one. In the face of possible breakdowns of raw materials, lack of suppliers, delays in transport, regulatory change, production breakdowns, increases in spending, shortages of human resources, among many others, companies must beforehand delineate plans and procedures to circumvent these constraints and thus be more resilient.

In this follow-up, digital technologies and methodologies can be taken as an alternative path or assist in their identification:

- Strategy Engineered — Technology is simultaneously a new competitive advantage for some organizations and a threat to the survival of others. As a result of this duality, the distinction between

corporate strategy and technology strategy is becoming diffuse. Corporate strategists are looking beyond the current technological capabilities of the organization and competitors. But the complexity of uncertainties and countless possibilities may be too much for the human brain to process, and it is in this context that technological platforms gain space by offering the ability to obtain advanced analytics through automation and AI.

- **Core Revival** — Modernizing enterprise systems and moving them to the Cloud can help improve an organization’s digital potential. However, the costs associated with this migration and other modernization strategies can impede for many companies. That’s about to change. In what is a growing trend, some pioneering companies are starting to use smart outsourcing agreements to modernize their business. Some are still exploring opportunities to shift key assets to increasingly powerful platforms, including low-code options. In a business climate defined by uncertainty, these innovative approaches may soon become standard components of each CIO’s digital transformation manual.
- **Supply unchained** — There is long considered a cost centre for business, supply chains are increasingly coming out of the back office and emerging at the forefront of customer segmentation and product differentiation. Manufacturers, retailers, distributors and others are exploring, focused on the future, new ways to turn the supply chain’s cost centre into a value-added asset for the customer. These stakeholders are drawing more and more value from the data they collect, analysing and sharing these insights in their supply networks. Some of these companies are even exploring opportunities to use robots, drones, and advanced image recognition.

Since resilience is seen as a priority for businesses, it requires from all management enormous economic stability, flexibility and increased responsiveness, detachment mindset (notably technology that gets obsolete with great ease), research and innovation.

By being resilient, industries can contribute substantially to society’s resilience by ensuring that production remains unchanged and that workers maintain their work. By being resilient, companies, rather than returning to their pattern of fragility and permeability, contribute to rebuilding a much more resilient and crisis-proof European economy and industry.

It should be balanced by the development of sufficiently resilient strategic value chains, adaptable production capacity and flexible business processes, especially where value chains serve basic human needs such as healthcare or safety.

In short, in Industry 5.0 the human being must be at the centre, resilience assumes itself as a key factor for success and sustainability is a business requirement.

3. Industry 5.0 enabling technologies.

3.1 Introduction

All the industrial revolutions have in their own way a group of technologies enabling and facilitating and even triggering those revolutions, i5.0 is no different. Here we discuss the technologies enabling the human centric, sustainable, and resilient revolution of i5.0.

3.2 Human-centric solutions and human-machine-interaction technologies machines

The Fifth Industrial Revolution aims to bring back the human workforce to the factory grounds. This will increase collaborations between humans and machines to advance human intellect and creativity further and boost process efficiency by merging workflows with artificial intelligence [40].

Industry 5.0 is predicted to synergise humans and autonomous machines or robots. The association of humans and robots in a seamless production process results in a highly efficient and valuable workflow, encouraging reliable autonomy, reduced waste and lowered production costs. Industry 5.0 is already changing the definition of the term "robot". Robots in manufacturing are programmable machines that can execute repetitive tasks and also, in some cases, provide a dependable human work aid. This concept introduces the following technological classification of robots, commonly known as cobots or collaborative robots, that quickly learn new movements and are adaptable. The collaborative robots are aware of the human presence, and they consider safety and risk criteria. Like an apprentice, the cobots need to be taught and learn how to perform a task and after this step, they can reproduce the indicated procedure as a human operator does. Therefore, the human worker feels satisfaction, even accomplishment, while working alongside a cobot.

Concerning the footwear manufacturing process, human-centric solutions and human-machine-interaction technologies are key aspects of Industry 5.0. These technologies and solutions can create a more seamless and efficient collaboration between humans and machines in the footwear industry.

Some examples of human-centric solutions that can be successfully applied in footwear manufacturing refer to the following technologies: Augmented Reality (AR) and Virtual Reality (VR), robotics and automation, sensors and Internet of Things (IoT), Human-Machine Interface (HMI) and Human-Robot Interaction (HRI), predictive maintenance.

Augmented Reality (AR) and **Virtual Reality (VR)** are technology solutions that can provide workers with real-time information and instructions and simulate different manufacturing scenarios, which can help improve worker training and reduce errors [41]. In the footwear sector, production is organised through the association of several manual and industrial operations, leading to the necessity of well-rounded teaching techniques. The expert knowledge of skilled operators is an essential ingredient that influences the

manufacturing processes and results. Training of human resources represents a vital step in maintaining knowledge and expertise in the company, thus reflecting high-qualitative end products and positive brand recognition. Also, it may prove a real tool for reducing staff turnover by minimising knowledge gaps. The AR and VR technology can guide operators in shoe closing, assembly and/or finishing production lines during the training activities. It is recommended to implement a dedicated training station adequately equipped rather than having the systems directly on the production line. Using a learning system based on AR and VR allows for shrinking the workload of expert operators in coaching activities and can enhance the learning curve and decrease the time needed to finalise a training induction program for new hires [42].

In practical use, Augmented Reality (AR) and Virtual Reality (VR) technology are already being used as part of the retail experience. For example, several footwear companies use these technological advancements to improve their operations and customer experience.

Adidas has developed an AR-enabled mobile app that lets customers to virtually try on shoes and see how they would look in different colours and styles. The app also includes a feature that allows customers to see how their shoes would look when worn by professional athletes [43].

Nike has also developed an AR app that allows customers to view and customise shoes in 3D; they can measure their feet virtually and then purchase items through the app. Additionally, the company has also developed VR training programs for its athletes [44].

Puma is another company that has developed an AR-enabled mobile app (LQD CELL Origin AR) that allows customers to see how shoes would look when worn, customise the shoes with different colours and styles, and play interactive games. The app also includes a feature that allows customers to see how their shoes would look when worn by professional athletes [45].

The sports company Reebok has also developed a virtual reality fitness program that allows users to work out in virtual environments with virtual trainers and other users [45].

Joining the trend, the New Balance company has developed an AR mobile app that allows customers to see how shoes would look on their feet and customise them with different colours and styles. The app also includes a feature that allows customers to see how their shoes would look when worn by professional athletes [46].

These examples show how companies are using AR and VR systems to improve the customer experience, allowing clients to try on shoes virtually and customise footwear to their preferences. The companies are also using VR technology for training and product development purposes.

Robotics and **automation** represent other human-centric solutions within Industry 5.0, as they enable the integration of advanced technologies and the implementation of smart manufacturing processes. Robotics and automation in Industry 5.0 are characterised by the use of advanced technologies such as artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) to enhance the performance and capabilities of robots and automated systems [47].

Specifically, in the footwear industry, robotics and automation could *improve the efficiency and productivity of manufacturing processes*. For example, robots are increasingly used in footwear production to perform repetitive tasks such as cutting, stitching, and assembling. Automation improves the production process's precision and accuracy and boosts speed and efficiency. Additionally, the use of robots and automated systems in the production process has also enabled companies to reduce labour costs, improve working conditions for employees, and help minimise the risk of injuries to employees. One of the key developments of Industry 5.0 is the *emergence of cobots*, which are *collaborative robots designed to work alongside humans in the same workspace*[48]. The use of cobots in the production process allows for a more flexible and adaptable workflow as they can be easily programmed to perform various tasks, assist workers with operations such as material handling or assembly, and adjust to the human worker's pace.

Another area where robotics and automation have significantly impacted the footwear industry is the development of *customised and highly personalised shoes*. Using technologies such as 3D printing and advanced materials, companies can create shoes tailored to customers' needs and preferences. This has been made possible by the additional use of *digital twin technologies* that are also an integrated part of Industry 5.0, which enable companies to create virtual representations of footwear models and production processes and simulate how they will perform in real-world conditions. In addition, the use of robotics and automation in Industry 5.0 has also led to the development of *new business models*, such as mass customisation and on-demand manufacturing [48], which allows companies to quickly and efficiently adapt to customer demands. This can be seen, for example, in companies such as Adidas, which experimented with automated robots and manufacturing mechanisms to produce shoes on demand and in real-time at its Speedfactories [49], but other companies such as Nike and Gucci are taking note as well [50].

Robotics and automation also play a key role in Industry 5.0 in *logistics and supply chain management*. For example, in the footwear industry, robots and automated systems are used to manage and optimise the flow of materials and products through the supply chain, enabling companies to improve their delivery times and reduce costs.

Sensors and the **Internet of Things** (IoT) are part of other essential systems of Industry 5.0 that revolve around human-centric solutions. They are used in the manufacturing process, allowing for real-time monitoring of machine performance and worker safety, which overall can help to improve efficiency and reduce downtime caused by machinery malfunction or worker injury. Sensors collect data about various aspects of the production process, such as temperature, pressure, and humidity. These data can then be analysed to identify improvement areas and make real-time adjustments to the production flow. For example, in the footwear industry, sensors can be used to monitor the temperature and humidity in a factory, ensuring that the conditions are optimal for the production process and that the final product meets quality standards. Sensors are also easily incorporated into machinery and robotics, allowing for the constant perception of measurements and human worker positions to reduce risks and accidents on factory premises. At a user level, sensors can also be embedded into footwear, creating a more immersive experience during use and increasing customer satisfaction[51].

The IoT is another significant technology in Industry 5.0, as it allows for seamless data transmission and sharing between devices, machines, and systems. In addition, the IoT can connect various production systems and machines, allowing for real-time examination and control of the production process. For example, a footwear manufacturer could use the IoT technology to connect a machine that produces the footwear sole with a machine that applies the uppers, allowing the latter to be adjusted in real-time based on the specifications of the sole (change in size, for example).

Human-Machine Interface (HMI) and Human-Robot Interaction (HRI) technologies are components of Industry 5.0 that allow a natural and intuitive interaction between humans and machines, which can help improve worker productivity and work satisfaction. These technologies facilitate the full cooperation of humans and machines on the production line. By creating intuitive and user-friendly interfaces, HMI and HRI have certain benefits, such as increased efficiency, reduced errors, and improved overall quality of the production process.

In the footwear industry, HMI and HRI technologies have already significantly impacted. For example, companies are using these technological advancements to create Augmented reality (AR), and Virtual Reality (VR) systems that empower workers to visualise and interact with virtual representations of footwear or leather goods and production flows. As a result, they can identify and address issues in real-time, reducing waste and optimising the overall production process.

Another example of the practical use of HMI and HRI technologies can be found in the use of collaborative robots (cobots) in the footwear industry. Cobots are designed to perform alongside human workers, using advanced and intuitive HMI and HRI technologies to interact with their human counterparts. Cobots must be adaptable and easily *programmable to perform tasks such as material handling, quality control, and assembling*, freeing human workers to focus on more complex tasks [52].

Predictive maintenance as part of human-machine-interaction technologies of Industry 5.0 uses data from sensors and other monitoring systems to predict, anticipate and prevent equipment failures before they occur, allowing for repairs or maintenance to be scheduled in advance. By using advanced sensors and data analysis techniques, predictive maintenance systems can detect subtle changes in equipment performance and predict when maintenance is required. This concept has evolved from an Industry 4.0 principle, transforming traditional production processes into intelligent sensor-equipped manufacturing plants where technology is pervasive [53]. However, previous iterations of this principle failed to consider the human factor and how predictive maintenance systems affected the decision-making process. As a component of Industry 5.0, predictive maintenance implementation is envisioned by applying technological frameworks that transform the company, work environment, and manufacturing tasks [54].

With specific regard to the footwear industry, predictive maintenance has already begun to have a significant impact. For example, companies are using predictive maintenance systems to monitor the performance of their production equipment, such as injection moulding machines, conveyor systems, and cutting machines.

By identifying issues before they cause equipment failure, factories can reduce downtime and improve production efficiency. This can result in *significant cost savings and improved product quality* for footwear companies.

Overall, the principle of human-centric solutions and human-machine-interaction technologies is a complex concept that evolves from the classic view of Industry 4.0, incorporating human benefits and worker input. These systems work in synergy and are interconnected in their applications. As part of the new industrial revolution, they will improve the efficiency and safety of the manufacturing process and increase the collaboration between humans and machines in the footwear industry.

3.3 Bio-inspired technologies and smart materials

Bio-inspired technologies and **Smart materials** are other facets of Industry 5.0, impacting primarily environmental principles as they aim to protect and improve climate conditions and human experiences. These technologies and materials are designed to simulate the properties and functions of natural materials and systems and are enhanced with embedded sensors and technological features that allow them to be sustainable and, at the same time, recyclable [55]. Bio-inspired technologies, together with smart materials, play a critical role in the future of manufacturing and the goal of reaching a zero-waste economy. These technologies incorporate fundamental principles such as reducing production and end-of-life product wastes, also known as closed-loop supply chains by optimising raw material consumption, extending the lifetime of necessary resources, and exploring solutions to industrial obstacles from examples found in nature (biomimicry) to create more efficient, sustainable, and responsive materials.

In the footwear industry, using bio-inspired technologies and smart materials is already impacting companies striving for a competitive edge. For example, companies such as Nike and Adidas have adopted innovative materials and are using smart materials with *integrated sensors that analyse external stimuli*, such as heat or pressure to monitor user performance and optimise comfort specifications [56]. This empowers them to bring to market footwear that is more responsive to user needs and provides a better fit for the wearer.

Another purpose for bio-inspired technologies and smart materials in the footwear industry is to allow the production of environmentally friendly shoes that are easily *recyclable or biodegradable* and can decompose without leaving harmful residue in nature. In the long term, this type of footwear is predicted to have a lower environmental impact and be more sustainable. For example, the UltraBOOST, 'Made to Be Remade' from the company Adidas [57], is a sports shoe made without any dyes or glues aimed to be completely repurposed after its use. In addition, the upcoming Nike ISPA sneakers (improvise, scavenge, protect, and adapt), named the ISPA Link and ISPA Link Axis, are built around a *circular design* principle with the goal of convenient "disassembly" where the product could easily be recycled, holding it to a smaller carbon footprint and extended life cycle [58].

Materials that are designed to *simulate the properties of natural sources*, such as spider silk or shark skin and can be used to create lightweight, strong, durable and eco-friendly components are also included in the category of bio-inspired technologies. They can be *self-healing materials* that can repair themselves when

damaged, increasing the lifespan of footwear and reducing the necessity for frequent repairs. *Shape-memory materials* are as well included in this category, as these materials can be generated to return to a specific shape after being stretched or deformed. They are increasingly being used in producing footwear that adjusts to the wearer's foot shape, providing a better fit, support and increased comfort.

Comprehensively, the integration of bio-inspired technologies and smart materials as part of Industry 5.0 is a significant boost for the footwear industry, and the market's competitiveness is continuously pushing technological thinking and other advancements. These technologies grant companies the ability to create footwear designs that are more efficient, sustainable, and responsive to the wearer's needs and, at the same time, provide significant cost savings and improved product quality for the ultimate benefit of customers.

3.4 Real time-based digital twins and simulation [1]

Digital twin technology and **simulation** are two distinct components of Industry 5.0. They are connected because both use virtual model-based simulations, but a division between them should be cleared. This is needed because, even though they are commonly used as tools in product design applications, the functions for simulation of computer-aided design and engineering (CAD-CAE) are less capable than digital twin technology. Once created, a virtual CAD model passes to be a digital twin with the introduction of functions based on the Internet of Things (IoT) and Augmented Reality that will allow users to see and analyse how the product will behave in real-time or even to set up an operational production process [59].

As stated, simulations are tools used in all industries to test concepts and products to validate systems and processes. In most cases, they are developed during the design phase and are represented by digital 2D, or 3D models created using computer-aided systems and software design applications. Then, the logic behind a simulation is applied to test different design elements in a fixed digital environment or provide a juncture to assess the final elements. Evolving from this concept, a digital twin system represents a virtual model generated by precisely reflecting an existing physical item. The process requires fitting the real item with sensors and collecting data about performance in different scenarios. The gathered information is then processed and associated with the digital model. This digital twin model is then used to run simulations, analyse performance, validate solutions and test possible improvements that have the potential to be applied in real life to the physical product. The uses of the digital twin systems are not limited to physical, existing entities but also can be generated for various processes and concepts, as it allows the reproduction of real-time data to be used in simulations and optimisations.

Essentially, the most significant impact introduced by the digital twin simulation system is that it empowers the user to conduct business strategy analysis, convey improvements in operational efficiency, investigate the possibility of automation for manual tasks, gather and perform data analysis for production management, even to carry out advanced training sessions for employees. In this respect, an integrated IoT platform and sensor-enabled devices could create a closed-loop information-sharing stage.

Boeing is one of the companies that has adopted the digital twin system into phases such as design and production [60]. At their facilities, the IoT is used to sustain real-time monitoring structures that supervise

digitally-enabled tools and ensure worker safety to drive efficiency, create predictability and offer consistent quality and stability in their manufacturing processes.

Tesla is another example of a company that implemented digital twin systems in their vehicles. It is used to collect information to optimise their designs, sustain efforts to improve the concept of autonomous vehicles, generate safety and predictive analytics and supply data for predictive maintenance purposes [61].

In the footwear industry, real-time-based digital twins and simulation as part of Industry 5.0 are at their inception. The theoretical uses for these technologies are obvious, and their potential is being explored. However, real-life implementation is only in its infancy and research on the subject with applied purpose in the footwear industry is in progress.

Digital twin technology allows manufacturers and designers to create virtual replicas of physical footwear that can be used to simulate and improve its performance in different conditions. This process can help reduce the need for physical prototypes while at the same time not affecting the identification and resolving potential issues before the product is manufactured. With the introduction of Virtual Reality and Augmented Reality (VR/AR), different manufacturing scenarios can be simulated, such as an assembly line and testing environments, which can improve worker training and reduce errors. There is also potential in creating virtual showrooms, allowing future customers to visualise and try on shoes in a virtual setting. Another application of digital twin technology in footwear industry is represented by predictive maintenance, which uses data from sensors and other implemented monitoring systems to analyse and foresee when a machine is likely to fail, allowing for repairs or maintenance to be scheduled in advance, ultimately reducing downtime and improving efficiency. Thanks to Machine Learning (ML) and Artificial Intelligence (AI), data from digital twins and simulations are analysed and can be used to identify patterns and employ automation in the production process, first tested virtually and, after validation, applied physically [62]. Regarding the benefits of simulation technology in the footwear industry, another application can be found in materials engineering. Digital twin technology could be used to simulate the behaviour of different materials, allowing engineers to identify the best combination of materials and methods to use in the production of footwear.

The first application towards real-time digital twin systems in the footwear industry has been taken by companies such as Dr. Martens, which has decided to implement a philosophy of "A single source of data for global manufacturing" [63]. By adopting a method of gathering all the relevant and accurate information in a single source, the production team at Dr. Martens has streamlined communication globally, collaborating with the supply chain in real-time. This means that changes and discrepancies in production are tracked internally for all their factories, and these data help the company to have visibility and better management over quality and cost and enact key performance indicators for its customers.

Overall, these real-time-based digital twins and simulation technologies can help to improve the efficiency and effectiveness of product design, manufacturing processes, and operational expertise in the footwear industry.

3.5 Cyber safe data transmission, storage, and analysis

The Industry 5.0 principles are continuously being integrated into modern manufacturing standard structures. The key enabler for this ongoing digital revolution is represented by data and how it is used as part of smart manufacturing processes. Although a building block of the industry, data needs to be collected, analysed and interpreted to provide valuable intelligence [62].

When considering the production environment, almost every part can be treated as a data source. Information such as the manufacturing system, human resource planning, customer base, process management or marketing strategy contains product, production, and supply chain data. Sensors are an essential source of raw data as they constantly monitor the factory machinery, their performance, and optimal operating conditions and, to some extent, track the whereabouts of semi-finished goods along the production process. In some applications, products are constantly connected to Internet and offer data to the manufacturer even after reaching the consumer. Thanks to the Internet of Things technologies and enabling Radio Frequency Identifications (RFID), data can be collected in real-time. Data acquired can be classified into three types: structured represented by digits or symbols, semi-structured defined by graphs, XML documents, and other similar content and finally, unstructured or raw data expressed by logs, sensors readings, and images. In order to store the sheer volume of data, especially unstructured data, systems such as cloud storage and big data storage technologies have been implemented at an efficient cost and as an energy-saving solution. The data generated needs to be analysed into purposeful information that can be easily transmitted to the personnel in charge and be used as real-time data on the shop floor. Considering this long chain of processes, the complexity, and the impact of data nowadays, cybersecurity becomes imperative in every domain of activity.

Considering smart manufacturing processes, cyberattacks have been studied in the scientific literature [64] focusing on "Manufacturing and Security Challenges in 3D Printing". It was concluded that embedded defects in the digital files used in additive manufacturing processes could affect the quality of the final products with a minimal chance of being detected in routine quality inspection procedures. The attacks compromise the CAD files, resulting in a compromised design file that provides flawed product specifications, rendering the completed product or process useless. For the footwear industry, cyber-safe data transmission, storage, and analysis are essential for ensuring the security and integrity of data in the manufacturing process. The safety of proprietary practices and smart and connected footwear approaches are needed to ensure customer data safekeeping.

If we are to divide this larger concept of cyber-safe data transmission, storage, and analysis into its components the following notions are identified: ***secure data transmission, secure data storage, cybersecurity, access control and authentication, data analysis and blockchain.***

Secure data transmission technology ensures that data is transmitted securely between devices and systems, using encryption and other security measures to protect against unauthorised access or manipulation.

Secure data storage technology guarantees that data is kept securely, using encryption and other security measures to protect against unauthorised access or manipulation.

Cybersecurity technology aims to protect systems and devices from cyber-attacks, such as malware and hacking, using firewalls, antivirus software, and other security measures. This specific point has become vital in today's data protection measures.

Access control and authentication technology ensures that only authorised personnel have access to sensitive data, using methods such as passwords, biometrics, and multi-factor authentication.

Data analysis technology can be used to examine information from the manufacturing systems. For example, sensor data help to identify patterns and trends that can be used to optimise the design and manufacturing process.

The **blockchain technology** can be used to create a tamper-proof and secure digital ledger of transactions, which can help to ensure the integrity and security of financial data in the manufacturing process [65]. Blockchain technology is also a key component in implementing intelligent solutions for traceability purposes. With the current sustainability trend evolving, traceability and sourcing of materials becomes an active subject that will involve companies, manufacturers and customers in a constant free flow communication. In the textile industry for example it is being proposed the introduction of an accountability app that will map the global supply chain of fabrics and accessories, holding brands liable to transparency in their policies, social endeavours and environmental production approaches [66].

3.6 Artificial Intelligence

Artificial intelligence (AI) is one of the Industry 5.0 pillars that is increasingly integrated in manufacturing, relating to design approaches, responsibilities division, and real-time dynamics actions. Artificial Intelligence is based on algorithms and systems that can provide understanding of complex notions and contribute to the automation of specific tasks, fully or even partially. This autonomy in functioning does not however eliminate human input or even decision-making which remains crucial in some instances or processes.

The existing literature distinguishes several types of Artificial Intelligence, depending on the amount of data handled and the scope of the applied science. From this division, we encounter the concept of *General Artificial Intelligence*, which aims to observe large amounts of information and create systems capable of reasoning and analytical thinking similar to human beings, and *Narrow Artificial Intelligence*, that is directed towards specific problems with the goal of solving through automation specific and repetitive tasks. Industrial manufacturing is based on the use case of Narrow Artificial Intelligence applied to industry [67].

Some examples of the practical use of AI related to Industry 5.0 in the footwear field include the *CURREX InsoleFinder* and the *Digitsole Smart Insoles* technology.

CURREX InsoleFinder defines itself as a new type of online purchasing counselling made possible through the digital AI-based technology. Through the app attached to the online store, customers can configure the shape and the right fitting 3D insole adapted to their foot shape and also shoe type. The AI technology measures the foot inner arch based on a clear photo and then optimises the recommended shape of the

insole. The CURREX development team examined over 10,000 feet and with the help of sports scientists developed and trained this type of unique artificial intelligence. The company CURREX also claims that the digital solution includes a sustainable aspect that reduces the CO₂ footprint, by providing the best online advice before purchasing, guaranteeing increased comfort of the footwear, thus minimising significantly the risk of returns [68].

Digitsole Smart Insoles technology takes the approach of monitoring the mobility and gait patterns in order to analyse health issues and improve physical and mental wellness. The company considers walking a vital digital biomarker for health concerns such as Parkinson's disease, diabetes and many others, and by understanding mobility data inputs like stride length, impact force, pronation / supination among others, physical wellbeing can be maintained, and warning signs can be detected in advance [69].

Artificial Intelligence technology can be applied to perform a wide range of tasks that normally require human intervention, such as learning, decision making, and problem-solving. In the footwear industry AI-powered systems that can be used to automate the repetitive tasks, such as quality control, which can help to improve efficiency and reduce the need for human labour. Also, AI-based systems can that be used to predict when a machine will fail, allowing for repairs or maintenance to be scheduled in advance to reduce downtime and improve efficiency. Personalised fashion is another global trend in the use of Artificial Intelligence as it can be used to analyse data from customers, such as foot shape and gait, to create highly customised and personalised shoes, optimised in design by simulating the behaviour of different materials and manufacturing processes, to identify the best combination of materials and methods to use in footwear production[70].

We are currently seeing an uproar in the use of chatbots and virtual assistants online and based on their pattern of learning it is not difficult to envision their implementation in the footwear environment by providing customer service and support, helping customers to find the right shoe and answering their questions. Overall, AI technology is an alluring innovation that is an integrated part of Industry 5.0. Considering we are only at the beginning of exploiting AI-based systems in the footwear industry, businesses are still exploring the potential uses of this technology.

3.7 Technologies for energy efficiency and trustworthy autonomy

Industry and manufacturing are a powerhouse for societal and economic growth since that first industrial revolution and it continues to be considered as such as we enter the Industry 5.0 era. As the demand for goods and quality services is increasing, it has been recognised that the new challenges are posed not by financial markers solely but by sustainability and environmental concerns also. As industries are rethinking their operational efficiency and moving from traditional processes to smart technologies, it is becoming more obvious that energy sources and production need to step away from power hungry wasteful systems and incorporate sustainable solutions.

Technologies for energy efficiency and trustworthy autonomy are important aspects of Industry 5.0 in the footwear sector. These technologies can help to improve the efficiency and sustainability of the manufacturing process and also ensure that machines and systems operate in a safe and reliable manner [71]. The

European Union has taken an active role in the subject and has initiated several approaches for greener technology, mostly aimed towards Digitising European Industry, meaning better use of big data and incorporating artificial intelligence. Increased industrial production usually requires increased amounts of energy and higher carbon emissions. Innovative technologies can reverse this action by adopting intelligent production planning and using more energy-efficient technologies [72].

Thanks to increased environmental and societal awareness from the general public, companies are incorporating sustainability strategies into their business models. Some examples of technologies for energy efficiency and trustworthy autonomy include technologies such as LED lighting and variable speed drives that are energy-efficient and can be used to reduce energy consumption and costs in the manufacturing process. Because electricity is considered the future of the carbon-neutral energy system, renewable energy technologies are the focus of current trends. These systems, such as solar panels and wind turbines, are thought to be sources to generate clean, renewable energy that can be used to power the manufacturing process, although more research is needed in order to fully conclude on their benefits compared to production and expenditure costs. Together with new electricity production sources is growing the demand for intelligent energy management systems that can be used to optimise energy consumption by monitoring and controlling the energy usage of different machines and systems in real-time.

When it comes to the subject of trustworthy autonomy, we are already seeing implementation in the area of autonomous vehicles but also autonomous systems such as robots and drones that operate in a safe and reliable manner. In the footwear manufacturing industry autonomy of intelligent machinery is achieved by incorporating safety mechanisms and monitoring and control systems to detect and correct any errors or malfunctions.

Scientific experiments performed in footwear industrial manufacturing on the subject of upper manufacturing automation process and sole manufacturing automation process propose the introduction of robots in performing routine tasks such as drawing the gauge line, roughing and cementing the uppers to the sole, adhesive spraying and pressing for shoe assembling. Thought experiments are showing a parity in production time between the skilled human worker and the automated system, the real benefit comes from protecting human operators from harmful toxins and exposure to chemical substances generated by the adhesives used in footwear manufacturing, at the same time reducing the risks for errors caused by menial task repetition [73], [74].

Overall, these technologies for energy efficiency and trustworthy autonomy can help to improve the efficiency, sustainability, and safety of the manufacturing process in the footwear industry by reducing energy consumption, generating renewable energy, ensuring the safe and reliable operation of autonomous systems, and providing real-time monitoring and control.

3.8 Conclusions

Industry 5.0 offers a clear path to a more resilient, sustainable and human-centric industry and society. Through its impact, smart manufacturing technology has the potential to prosper and surpass traditional

manufacturing techniques. As it was observed in the above topics, Industry 5.0 technologies such as robotics and automation can significantly increase the speed and efficiency of the manufacturing process, reducing downtime and increasing output. The use of sensors, analytics, and machine learning can lead to higher-quality products by allowing for real-time monitoring and adjustment of the production process. Smart factory technology allows for a more flexible manufacturing process that can adapt to changing market conditions and customer demands increasing the customisation capabilities. This allows for a more rapid response to market changes and allows for the production of a wide range of products. Through the use of IoT, manufacturers can have real-time access to all the production data, giving them visibility to monitor, analyse and optimise all production processes in a more efficient and effective way.

Ultimately, the Industry 5.0 technologies such as automation, analytics and IoT enables companies to optimise resources, reducing waste, energy consumption and environmental impact, while maintaining, in some cases increasing production speed, quality, and efficiency, reducing the cost of production and making it more profitable for the manufacturer.

Industry 5.0 also allows companies to gather customer data and feedback, creating opportunities to personalise products, services, and customer experience, resulting in a more satisfied customer. Worth mentioning that the Industry 5.0 approach allows companies to be more resilient to disruptions through the integration of digital technologies that enable remote monitoring, control, and decision-making, allowing them to quickly respond to disruptions and minimise the impact.

An example of footwear that could potentially be created using Industry 5.0 technologies may include a combination of systems such as 3D printing, data analytics, and machine learning to create a shoe that is customised to the individual needs of each customer. The process would work as follow:

- The customer would first go through a series of tests, such as foot scans and gait analysis, to determine their unique biomechanical needs and preferences. These data would be collected and analysed using data analytics and machine learning algorithms, to generate a custom shoe CAD design that is tailored to the customer's specific needs and preferences.
- The shoe would then be 3D printed using materials that are optimised for performance, such as lightweight and durable components, including bio-based materials.
- The final product would be equipped with IoT sensors that can track the usage of the shoes, providing real-time information about wear and tear and providing insights on how to improve the design for the next iteration.
- After the customer has used the shoes for a period of time, the company could use the data collected from the IoT sensors to generate additional data for the machine learning algorithms to improve the design for the next iteration of the shoes, providing an even better fit for the customer.
- When the customer needs to discard the product, the company can collect the used footwear and recycle or reuse the materials safely.

This is just one example of how Industry 5.0 technologies could be used in the shoe industry, but there are many possibilities when it comes to the integration of advanced technologies such as IoT, machine learning, and 3D printing in the manufacturing process.

The transition towards Industry 5.0 and the implementation of smart factory technologies is a dynamic, ongoing process. Specific steps were identified and can be taken by the industry to move closer the 5.0 goals and some of these steps include:

- Identifying areas in the manufacturing process that can be improved through the use of advanced technologies such as robots, sensors, and analytics.
- Investing in the necessary hardware and software to support the implementation of Industry 5.0 technologies.
- Training employees to work with and maintain these technologies.
- Developing a roadmap for the implementation of Industry 5.0 technologies, including a timeline and budget.
- Collaborating with partners and suppliers to ensure that all necessary technology is in place and working together seamlessly.
- Regularly reviewing and updating the implementation plan as needed to ensure that the company is making progress towards its goals.
- Evaluating the results of the implementation to determine its effectiveness and make any necessary adjustments.
- Creating a flexible production system that can adapt to changing market conditions and customer demands.
- Implementing big data and advanced analytics in order to gain real-time insights into production processes and optimise performance.
- Creating cyber-physical systems to integrate and coordinate all the physical and digital elements involved in the production.
- Adopting a system-wide approach to ensure the integration of all the processes, systems, and devices, across the entire manufacturing ecosystem.
- Building and fostering a culture of innovation, experimentation, and continuous improvement.
- Incorporating smart technologies such as Industrial Internet of Things (IIoT), cloud computing, and edge computing to enhance the capabilities of smart factories.

These are some general steps that can be taken to move towards Industry 5.0. However, the specific steps will depend on the individual company, its manufacturing processes, and its goals.

4. Market and manufacturing opportunities in i5.0

4.1 Introduction

A more committed industry.

Previous industry eras focused on mass production. From mechanisation and steam power, to electricity, to automation. It has been all about how much, how quickly, and how cheaply a business can produce their product.

Moving away from that, Industry 5.0 aims to provide mass customisation, to create a super-empowered customer.

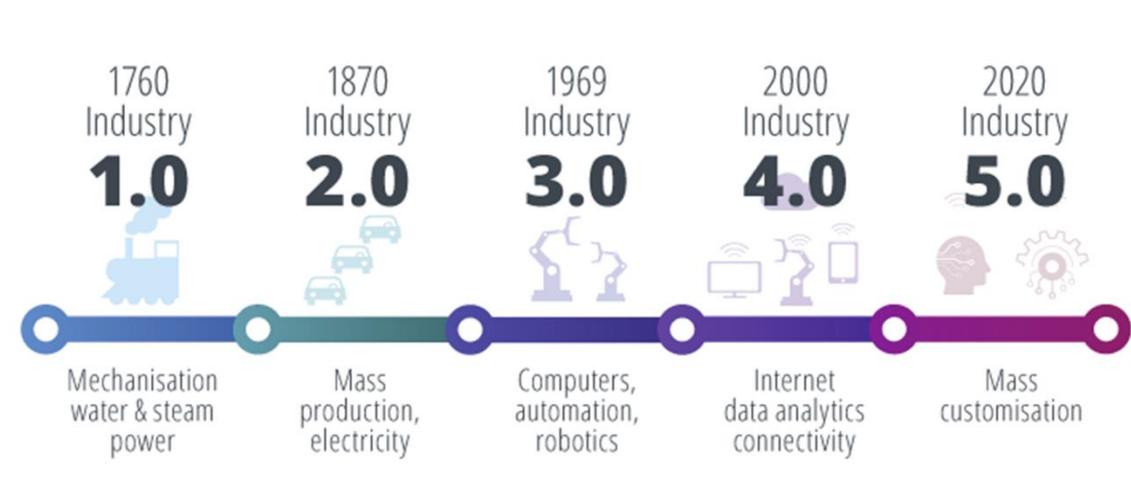


Figure 6. Major revolutions in the industrial process.

4.2 How will industry 5.0 shake up marketing?

Industry 5.0 offers benefits for a bunch of industries, for workers, and for society. It provides a vision for the future that goes beyond efficiency and productivity as the main aim and reinforces the role and contribution of industry and business to society.

Rather than green-washing, Industry 5.0 works to support the environment. It favours circular production models and supports technologies that make the use of natural resources more efficient. This will build trust with customers, who have increasingly looked for societally conscious 'added extras' in their choice of businesses.

Supply chains have disrupted all types of industries and have damaged relationships with customers. Revising existing value chains and energy consumption practices can also make industries more resilient against disruptive events, such as the Covid-19 pandemic.

Industry 5.0 also contributes to three of the European Commission's priorities: "An economy that works for people", "European Green Deal" and "Europe fit for the digital age". This is on top of the following aspects already being part of major commission policy initiatives:

- Adopting a human-centric approach for digital technologies including artificial intelligence ([Proposal for AI regulation](#))
- Up-skilling and re-skilling European workers, particularly digital skills ([Skills Agenda](#) and [Digital Education Action plan](#))
- Modern, resource-efficient, and sustainable industries and transition to a circular economy ([Green Deal](#))
- A globally competitive and world-leading industry, speeding up investment in research and innovation ([Industrial Strategy](#))

So, the curiosity, design, and understanding of how products are needed, used, and purchased becomes less tied into the manufacturing process. Think turning how we approach customer experience mapping and audience insight on its head.

4.3 Customer Experience [75]–[78]

4.3.1 What Is Customer Experience and Why Does It Matter?

In increasingly competitive markets, customer experience (CX) can be the key differentiator between businesses, which is why companies are working so hard to improve in this area.

Customer experience is something that evolves with the way consumers interact with brands, the technology, and channels they use, and the expectations they have around CX.

Behavioural changes brought about by digital technology and accelerated by the Covid-19 pandemic have increased the necessity of providing a great experience, while also making it even more of a challenge for brands.

In this article, we'll look at what customer service is, the difference it can make, and how businesses can improve the experiences their users have.

What is customer experience (CX)?

Let us start with a definition. Wikipedia describes it like this:

"Customer experience is a totality of cognitive, affective, sensory, and behavioural consumer responses during all stages of the consumption process including pre-purchase, consumption, and post-purchase stages."

Or, in plain English, customer experience is the total sum of a customer's interactions with a few and how they feel about the brand as a result.

This takes in everything - marketing communications, website and app visits, the purchase and delivery process, and any contacts with customer services.

It shouldn't be confused with user experience (UX), which mainly looks at how people interact with websites and apps and looks to make things as easy to use as possible.

User experience does contribute towards the customer experience though, along with customer service, marketing, and sales.

Why does customer experience matter?

A good CX is likely to mean that the customer achieved everything they wanted to do easily, the site was easy to use, delivery was smooth, and so on.

Good customer experience has positive impacts:

- **Acquisition.** New visitors are more likely to make a purchase, or to become potential leads.
- **Conversion.** Leads are more likely to become customers if they enjoy the experience, are impressed with content, etc.
- **Loyalty.** Customer retention rates improve.
- **Reputation.** Customers are more likely to recommend your company to friends, family, and colleagues, or to leave positive reviews.

While there are many factors that contribute to customer experience, just one part of the chain can turn good CX into bad - a checkout that annoys the customer, a failed or late delivery, or poor after sales service.

A negative customer experience can have several effects, all of which are bad for business:

- Lost sales opportunities.
- Losing customers to competitors.
- Negative reviews and word of mouth.

The role of CX in digital transformation

The digital transformation that has been taking place in organisations since the growth of online is based around a reaction to changing customer behaviour. It is about improving the customer experience.

As more people find it convenient to interact with businesses online, the more businesses need to adapt to digital, providing services across the channels that customers prefer, or as they move between channels.

The Covid-19 pandemic has accelerated digital transformation programmes (by up to seven years according to some estimates) by highlighting their performance when only digital channels are available.

Data from McKinsey shows how digital interactions with customers increased during 2020. In July 2020, the majority of all customer interactions were conducted via digital channels, compared to 36% just a few months before.

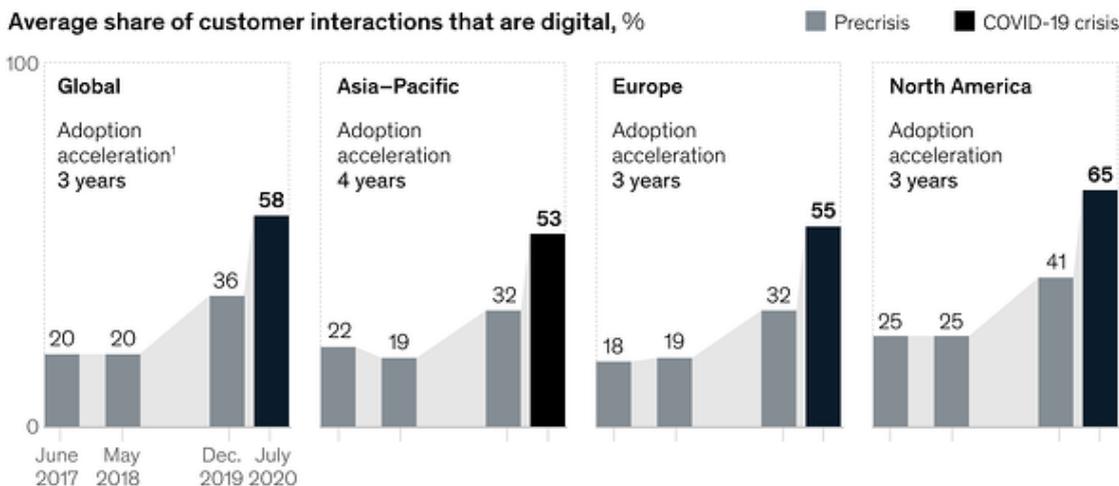


Figure 7: Evolution of user interaction trends.

In the light of this customer behaviour, those organisations which were slow to digital, or even dismissed the online channel, were shown just how important it is.

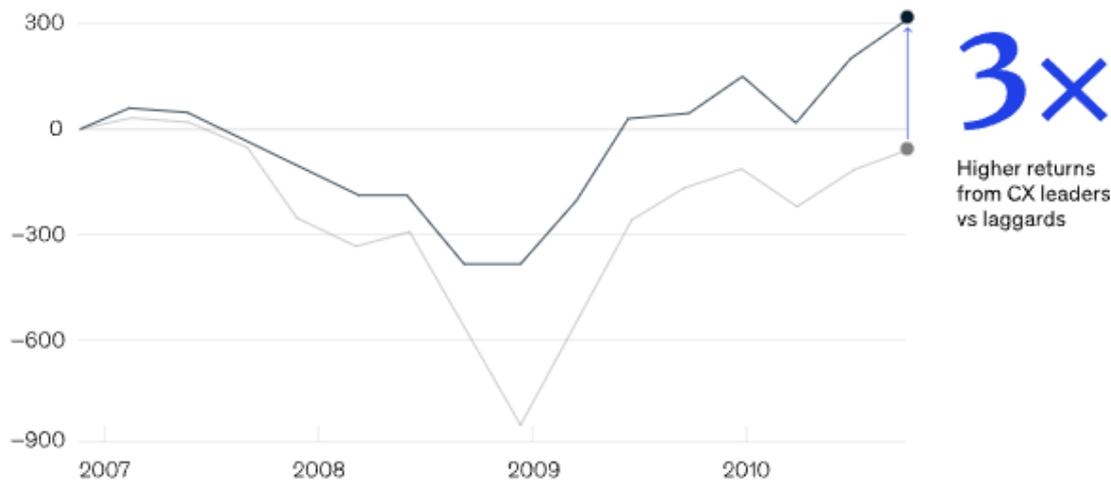
It is also important to note that this shift in customer behaviour was the forced acceleration of an existing trend, so it's a new reality rather than a passing phase.

This is where customer experience matters. Great CX helps those companies to be more resilient, and to recover from difficult periods.

McKinsey's analysis of the 2008 global financial crisis found that customer experience leaders rode the downturn more effectively and rebounded more quickly.

Customer experience (CX) leaders are more resilient during recessionary periods, experiencing shallower troughs and quicker recovery.

Financial performance (total shareholder returns) of CX leaders vs laggards¹



¹Comparison of total shareholder returns for publicly traded companies ranking in the top ten of Forrester's CX Performance Index from 2007–09. Source: Forrester Customer Experience Performance Index (2007–09)

Figure 8: Companies that bet on better CX respond better to economic downturns.

Likewise, the companies that have already put the customer at the heart of their strategy and adopted digital were more able to weather the challenges during the pandemic.

For example, Primark's reluctance to sell online saw it lose more than £1bn in sales during 2020, while LVMH, which was in the process of digital transformation when the pandemic struck, saw its revenues fall by 17%.

Using the automation and cognitive machinery from robot technology, you can produce what you want. Then, on the customer side, they can specify whatever variety of product they want, since efficiencies in manufacturing allow for greater flexibility. All of this can mean a greater offering of personalisation, even for the most niche requests, without additional costs or delay.

But the changes Industry 5.0 are making are not just on the customer side. This change will also require some element of training and a focus on talent. Whereas in the past purely digital skills were pushed, some deal of focus will be put on the more creative side of training.

The changes will also lead to a force of 'empowered workers', who can rely on improved safety and well-being, hybrid working, and even a four-day work week. So, industry 5.0 makes topics in the 'future of work' debates a genuine possibility.

So, think empowered workers, evolved skills, and training needs met. This increases the competitiveness of industry and helps attract the best talent.

Plus, the automation achieved during industry 4.0 will allow workers to free themselves from repetitive, boring, time-consuming tasks, and allow them to focus on crafting more powerful strategies or applying their creativity.

But how does this specifically apply to marketing? Well, industry 5.0 is shaking up:

4.3.2 Customisation and Personalisation

The digital tools that will stem from the industry will give the client the ability to create their own, hyper-specific items, experience personalised engagement, and enjoy realistic and engaging experiences, from the combination of high tech and creativity.

The customer experience will be improved through the removal of the need to wait for an item to be placed back in stock. If the product is only produced after the purchase, the brand benefits too. This means no dead stock, so no dead money.

Technological innovations alone do not allow for the degree of personalisation that meets the needs of customers. The workers who are part of 5.0 will leverage the potential of technology but will also find the space to add their own ideas, which will lead to a product which is developed with personalisation in mind.

4.3.3 Customer Relationships and Customer Retention

Industry 5.0 allows marketers to always keep their customer in mind, and focus on ways of identifying issues, and improving the relationship. This might look like using:

- **Cyber Physical Cognitive Systems.** Combining the capabilities of human and artificial intelligence systems to optimise performance and purpose. This means day-to-day tasks are streamlined, so marketers can turn their focus on the customer.
- **Transparency.** The combination of highly efficient automation, and the human element, can help keep trust high.
- **Enterprise Agility.** Promoting celerity in every area of the business to improve efficiency. With today's rapidly changing customer demands, enterprise agility will help deal with such prompt shifting situations.

So, Industry 5.0 aims to keep the customer happy. This looks like the faster assimilation of specific needs, and faster and cheaper production.

And from this satisfaction comes a better outcome for the marketer. They will see increased customer retention and happiness, and through it all, a better customer experience.

All of this can benefit B2B marketers, who have struggled to adapt to the B2C mindset of their customers.

B2B customers now expect the same level of personalisation, care, and relevance that their B2C counterparts receive. So, through these innovations, marketers can use sophisticated digital marketing activity across all channels to connect prospect customers directly to the manufacturing process.

CRM, marketing automation, machine-learning personalisation, AI and VR will all have a more visible and viable role in the new industry, due to the now achievable digital transformation of the entire supply chain, right through to the customer. And alongside the creativity of the human supporting it, customers will receive a customer experience like never before.

4.4 Mass production [79]–[83]

4.4.1 New trends in industrial mass production (Transition from 4.0 to 5.0)

Although Industry 4.0 is still a work in progress for many businesses, the relentless march of progress continues. Industry 5.0 is the next step in the evolution of manufacturing, and to remain competitive, production and manufacturing processes must adapt to the change. If you need proper motivation, just imagine the market as the lion and your business as the gazelle. It's in your best interest to stay a step ahead.



Figure 9: (Artistic representation) How cyber-physical systems report data in real time.

Industry 4.0 Walked So Industry 5.0 Could Run

It is best to think of Industry 5.0 as the natural evolution of Industry 4.0. Both address fundamental concerns, such as digital transformation, which connect the supply chain to manufacturers and other stakeholders to assure quality, product availability, product customization, and sustainable operations.

The changes brought about by Industry 4.0 have paved the way for the advancements that Industry 5.0 are now bringing to the table. Since the introduction of Industry 4.0, the manufacturing industry has been re-shaped by a wave of intelligent applications, mostly consisting of cyber-physical systems, in which applications interact via machine-to-machine communication. This progress has centred on sensors and data, which have democratized manufacturing and increased transparency in operations. These were valuable achievements, and it is fair to say Industry 4.0 had a good run.

So why should we change anything? Well, Industry 4.0 also has limitations. Its focus on automation was ground-breaking, but with all the focus on machines the vital role of human operators was pushed to the background. Machines are great when things are going as planned, but when unsavoury materials hit the proverbial fan machines lack the flexibility to diagnose and correct problems. What starts as a small error can escalate quickly. The next generation of advancements intends to address that little blind spot.

Our Returning Champions

Industry 5.0 builds on the foundations of Industry 4.0, keeping what works and improving what does not. As a result, some of the key components of Industry 5.0 in manufacturing are shared with Industry 4.0: Cobots, the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), and Smart Manufacturing. Let's look at what these tools have accomplished so far, and what they can offer to Industry 5.0.

From Robots to Cobots

Robots play a significant role in demanding tasks such as loading, unloading, welding, and so on. They're incredibly precise and don't mind at all when you put them in hazardous situations. As a result, industrial robots are one of the primary pillars of Industry 5.0 and will be utilized to mass-produce personal items.

However, Industry 5.0 is taking a more human-centric approach, so we're rebranding our mechanical colleagues with a title that fits their new role. **Cobots** (collaborative robots) are designed to work in sync with human employees. Mechanical muscle guided by human brains in Industry 5.0 boosts the pace and development of numerous operations at the same time. Contrary to what science-fiction may have implied the human brain will only be powering the robot metaphorically. This close collaboration between humans and machines will allow brands to meet the demands of clients with both **speed** and **flexibility**. And we all get to keep our brains.

Industry 5.0 won't replace man with machine, or vice versa. It opts instead for a happy medium where humans coordinate production leveraging the many advantages machines can offer. That way people can focus on problem-solving and finding creative solutions to problems while machines take care of the repetitive and uniform tasks.



Figure 10: An operator using a cobot in a precision task.

Internet of Things, Big Data and Artificial Intelligence

The Internet of Things (IoT) is sometimes a difficult concept to grasp, but it offers major advantages to those who understand what it represents. The IoT is comprised of every little gadget that connects online, not just computers, but also coffee makers, exercise bikes, or smart televisions. These devices can gather massive amounts of operational data in real time, and that data can then be used to inform decision-making at the production level.

All the information gathered by these networked devices is the vaunted "Big Data" you have heard so much about. But all that data is useless unless you can sort through it quickly to separate signal from noise. That is where Artificial Intelligence comes in.

AI technologies can collect and understand massive amounts of data from the factory floor to find trends, evaluate and anticipate customer behaviour, and detect abnormalities in production processes in real time. These solutions assist manufacturers in gaining end-to-end visibility of all production activities at plants scattered around the globe. Sifting through data is a monotonous task for a human, but to an AI finding the needles of valuable insight in those haystacks of information is light work. Can an expert weigh in on the benefits of AI? Ah, here we go:

*“Companies that use AI have seen cost reductions and revenue increases, according to **McKinsey**. Sixteen percent of those polled observed a 10-19% drop in costs, while 18 percent saw a 6-10% gain in overall revenue.”*

“Smart Manufacturing” is simply all the above elements combined, and once you have everything working in harmony, you’re now part of Industry 5.0. By using the nuggets of insight from Big Data gleaned from the Internet of Things, human operators can then make informed decisions and put Cobots to work for an efficient result. Incredibly, these are not all just buzzwords after all, these tools can make a real difference when implemented effectively.

So...This Is a Good Thing for Manufacturing?

Of course! Assuming your implementation is solid. All these factors combined result in a variety of positive outcomes for businesses. These technologies allow **digital decision-making** and, therefore, an intelligent business, with the combination of Cobots, IoT, Big Data, and AI. When an **intelligent business** is well-optimized it is inherently more efficient than a business that does not take advantage of these technologies. In laymen’s terms, people make better decisions based on data directly from the consumer than they do when they’re just blindly guessing what strangers might like.

As if that weren’t enough, Industry 5.0 will impress your inner Scrooge by employing the fewest resources to earn the largest revenues. You’re not being a cheapskate, you’re efficient! (But really, you’ll be both). The **reduction in manufacturing costs** will also give you an advantage against the competition. While others throw money away on a hunch you can make informed decisions and be confident, you’re getting the most bang for your buck before laying your money down.

Ruthless efficiency that crushes the competition is great, sure, but you also need a habitable planet to live on at the end of the day. Industry 5.0 has that covered too. One of the primary goals for Industry 5.0 is the development and implementation of industrial systems based on **renewable energies**. It advocates the use of **circular processes** that reuse and recycle natural resources, decrease waste, and have low environmental impact. And all that data-driven efficiency assists here as well, helping you get a clear picture of the production process to make it more environmentally friendly without sacrificing the bottom line.

4.4.2 Ultra-customisation of products



Figure 11: Customized products according to customer requirements.

In 1909 trailblazing industrialist Henry Ford famously quipped “A customer can have a car painted any colour he wants, so long as it’s black.” Thankfully, this unyielding attitude towards consumer preferences did not last long. As consumerism grew in the 20th century a variety of colours and patterns became standard for countless products. This shift occurred because customers demanded choices that reflected their unique style. Industry 5.0 is taking the concept to the next level by giving customers the ability to personalize an item from start to finish; shoes, laptops, and even automobiles can be customised with a variety of colours, parts, and features. Industry 5.0 will transition industries from mass production to mass customization, aiming to present customers with a product or a service specifically tailored to them.

What is Mass Customization?

Mass customization is a term that is discussed often in Industry 5.0 circles, and that is because it is an extremely powerful business concept. Many brands are embracing it because it is a good fit for both big companies and small entrepreneurs alike. Any brand that seeks to provide customers with a unique and personalised version of their products will benefit from embracing mass customization.

So, you may be asking, what qualifies as mass customization? **Mass customization** is a manufacturing technique that allows companies to create products that are tailored to the exact specifications of their customers.

The upside of mass customization is that by taking advantage of flexibility, integration, and **personalisation** to create custom-made items at near-mass production efficiency, it is possible to achieve an elevated level

of mass production while lowering unit costs. The customer gets exactly what they want while the company saves a bit on production costs. Everybody wins.

Considering those advantages, it is no wonder that customization is appearing in high-end boutiques selling handcrafted items, and it is spawning a whole new industry model where technology helps manufacturers produce custom products at a cost and scale comparable to mass production. In a manufacturing company, for example, flexible manufacturing technology is used to modify and adjust output in response to demand. This technique is also useful in many other sectors, including marketing, call centres, and management.

As a result, the current market is focused on creating a super-empowered customer that has a say in what their final product will look like, and as a natural result mass customization is on the rise.

From Mass Production to Mass Customization

Before the industrial revolution, manufacturing was regarded as a craft, and because things tended to be expensive and specifically produced to satisfy the demands of each individual buyer, access was confined to the upper class or aristocracy. The introduction of **mass customization** and **Industry 5.0** will allow every customer to get treatment that was once reserved for nobility. Manufacturing can now be done at scale, **on-demand**, for every customer. As humble peasants we, this is a welcome development.

One of the biggest downsides of **mass production** is the quantity of products that are produced, especially when companies produce standardised and uniform products. Through economies of scale mass manufacturing helps businesses cut their production costs, but without any ability to change course once massive orders have been created. In a worst-case scenario business can end up with mountains of unsold inventory.

On the other hand, in mass customization, businesses focus on differentiation: a business not only uses mass manufacturing, but also distinguishes its output based on consumer preferences. As a result, businesses can charge a premium for their products while both saving money and increasing their profit margins.

Mass customization has evolved as a technique that blends the best of both the craft and mass manufacturing eras. Although customized items may still be produced in large quantities, each item may change somewhat depending on the needs and desires of the specific end consumer. And this could not be done without the technology that is leading industries from different sectors to the new industrial revolution: you guessed it, **Industry 5.0**.

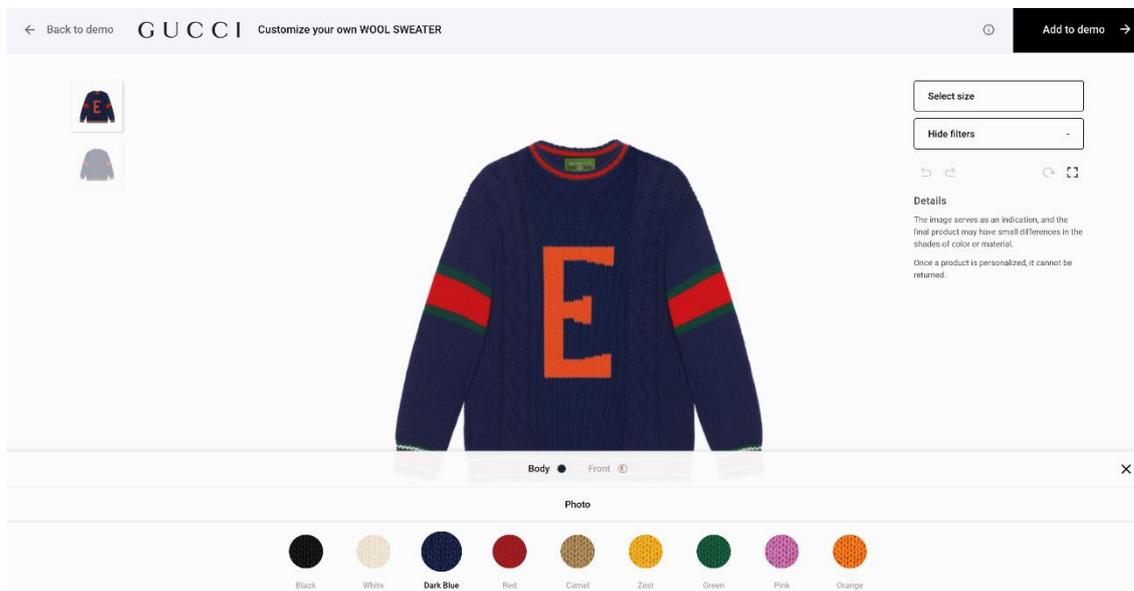


Figure 12. Customization using digital tools.

The Major Role of Industry 5.0 in Mass Customization

Industry 5.0 encompasses a human centric approach, meaning that it places essential human needs and interests at the centre of the manufacturing process, drifting away from a digital-driven development and toward a more personal and society-centric approach. It is surprisingly zen for an industrial revolution.

This new industry model understands human needs and desires as a priority, and that is exactly what mass customization is: applying customers' wants and needs to create products suited to meeting those needs. It sounds easy, but the technology doing the real work behind the scenes just makes it look that way.

Information technology (IT) and **automation** are critical to mass customization because they connect customer preferences to a manufacturing team's ability to build products based on those preferences. Therefore, customization will be limited by the availability of technology to perform this customization seamlessly. So, the better the technology, the better the customization experience and process.

In the same vein, companies must ensure that customised products arrive quickly to the final customer, without long lead times. With Industry 5.0 technology it is possible to create a system that enables easy communication between all side to ensure that the entire process is efficient. If this is achieved the customer's wait time for their order will be comparable to waiting for a restock of a typical mass-produced item.

Product customization has evolved alongside modern technology, like **3D** product creation. This type of technology enables companies, like PlatformE, to create **digital twins**, a digitally accurate representation of a real-life object. This facilitates the customization process, as it allows customers to see alterations in a very realistic way, so they can visualise their final product. These premium digital tools enable the client to create their own item, feel engaged in the creation process, and enjoy the hyper-realistic experience with nothing more than a device and their imagination. By leveraging modern technologies businesses can take the

guesswork out of customer preferences and let consumers do the heavy lifting by designing everything to their personal specifications.

There Are Still Some Challenges to Utilising Mass Customization Manufacturing...

Although consumers are now looking increasingly for personalised products, and mass customization brings real benefits for manufacturers, there are still many challenges to overcome.

First, it is hard to accomplish mass customization without an **efficient supply chain**. Yes, customers are willing to pay premium prices for customized products, but brands also must minimize production costs, shorten lead times, and still charge a reasonable price. So, supply chains must be efficient, and companies need to collaborate with suppliers that can provide quality materials on the fly and that are flexible enough for customization production. Second, technology is always evolving, and this approach cannot be supported by outdated technology. With new technology, new rivals may arise, making the firm less competitive. And there are still many companies that are only now experiencing and implementing the advances of Industry 4.0. Therefore, it can be difficult for companies to invest in modern technology.

In addition, dealing with product returns can be a problem. Usually, when a product is manufactured with customization, it is unlikely that it will be returned. However, this is still a possibility, and brands need to figure out what to do with returned goods that were made for that specific customer.

Finally, companies need to ensure that lead times for customised and personalised products are not excessively high. Since it is a complex system, it is important to come up with an efficient production line that ideally minimizes or eliminates lead times.

But the Benefits Are Very Appealing!

Of course, there are downsides to any business strategy, so let's not get too gloomy. Mass customization is an appealing business approach despite these caveats because it presents a variety of benefits for manufacturers, customers, and even the environment.

One of the obvious advantages of mass customization is that it offers a unique product. Tailored products are inherently exclusive, and few other customers or even competitors will have anything similar. Customers are extremely unlikely to accidentally wear the same outfit to a party as someone else if they personally designed their own outfit, so that's one less worry.

Minimising excess inventory and eliminating waste are undoubtedly some of the biggest benefits of mass customization. With mass customization, companies don't need to build up stock to sell, as personalised and customised products are **made-to-order**, meaning that they are only produced when they have already been sold. As such, inventory is not needed, and companies can sell on the fly. Mother Earth breathes a sign of relief as less unsold product ends up in landfills.

With mass customization, companies can offer a more satisfying sales experience. When customers have the option of customising items to match their individual wants and desires, it will organically increase consumer engagement and brand loyalty. Customers will have a stronger relationship with your company if they feel that they got something worthwhile for their money, or something that represents their individuality. Let customers tell you what they want and rake in the goodwill by simply delivering it.

Above all, for businesses to succeed, they must make fundamental and coordinated adjustments to how their company functions. Mass customization is not only about marketing and manufacturing; it's also about product research and development, supply chains, and technical infrastructure.

Mass customization is undoubtedly the future of production because customers are increasingly demanding more personalised products. Industry 5.0 is the core of this new era, applying innovations and technology to serve human needs, allowing people to realize the basic human urge to express themselves. Clearly it is necessary to have a range of technologies relevant to Industry 5.0 to make mass customization a reality, but making these products also requires what we call 'the human touch'. And that is what Industry 5.0 is really all about.

The Mass customization is becoming a reality because of the benefits of new and existing technologies working in harmony. Insights gleaned from Big Data can help manufacturers be confident they're producing a product that is exactly what their customer wants while preserving the environment for future generations. That's a win-win proposition.



Figure 13: An ultra-personalised product before it is shipped to customer.

4.5 Recapping and linking concepts.

Since the first **Industrial Revolution**, humans have understood the potential of applying technology for progress. The steam engine, the assembly line and the computer are just some of the advances that have taken place over the last few centuries, all aimed at generating ever more powerful technology and driving productivity and efficiency. The **Industrial Revolution 5.0** shifts this paradigm and is a revolution, as it calms the emphasis on technology and assumes that the real potential for progress lies in the collaboration between humans and machines.

Industrial Revolution 5.0 would bring the "human touch" back to manufacturing, promoting human-machine collaboration.

It has been more than a decade since the concept of Industrial Revolution 4.0 took hold. However, there is already talk of going one step further, the concept of **Industrial Revolution 5.0**.

If we look back at the different industrial revolutions, we see that their time of occurrence is accelerating. And although we know that each revolution had several periods, from its beginning to its end, we can say that the time between the first industrial revolution took about 100 years, and the time between the second industrial revolution and the third may have taken 60 years, and the time until the next revolution may have taken 40 years. If we consider Moore's law that says that processing doubles every period and associate it with industrial revolutions, there is no doubt that their frequency of occurrence is accelerating and that they will occur faster and faster, which leads to the idea that industrial revolution 5.0 would be no more than **20 years** away from industrial revolution 4.0, and so on. This is where the problem lies, because human adaptability to change is not advancing as fast as technology is changing, so that our understanding of technology and life around it will be impossible if we don't do something about it.

The industrial revolution 5.0, or the fifth industrial revolution, will bring hand in hand the interaction between man and machine. There will be a greater level of collaboration between workers and industrial robots, whose advanced technology makes them increasingly better equipped to work in tandem with human intelligence.

The phase leading up to the 5.0 industrial revolution has seen the development of digital industry: advances such as the **Industrial Internet of Things** or the joint work of **Artificial Intelligence and Big Data** have generated a new type of technology capable of providing companies with data-driven insight.

This, in turn, has translated into processes such as **Operational Intelligence** or **Business Intelligence**, which generates models that apply technology to make increasingly more accurate and less uncertain decisions.

However, during this phase in the 4.0 industrial revolution, the aim has been to minimise human intervention and prioritise process automation. To a certain extent, human beings have been made to compete with machines, displacing the former from a multitude of scenarios.

In the case of the 5.0 industrial revolution, this trend is reversed: the aim is to generate a **balance** in which **machine-human** interaction is able to provide maximum benefits.

The aim of the 5.0 industrial revolution is the formation of teams between robots and humans to realise the full potential of both. Collaborative work will result in a greater focus on human creativity in everyday life.

In the **industrial** revolution **5.0**, we will have a great development of Artificial Intelligence, which will allow us to have intelligent assistants with great capacities and brighter than the person himself, who will be able to provide great help in decision making and who will determine the competitive advantage of an employee in his position. Nanotechnology will make these assistants in a miniature microchip that can be housed somewhere in our body to have connection and with biotechnology, we can connect this tiny device to the connections of our body to hear, see and speak directly with the device as if it were inside our mind. This assistant will connect with all the devices in the house and car, as well as with third parties to place orders or evaluate proposals. So, the industrial revolution 5.0 brings with it a fusion of human and machine to develop a new type of person with greater capabilities and skills. It will be a person who will be able to identify when their interlocutor is hesitating, lying or not interested in what is being said, and thus be able to modify their conversation or body language to bring about the desired change. It will be a person who can easily calculate data and who will be able to perform more complex and sophisticated analysis.

At the same time, these types of assistants and devices will come in various qualities, which will vary according to price and manufacturer, so professional growth will depend on the quality of the assistant you have and the level of connection it allows between the device and the person.

One thing is clear: it is true that those organisations that focus their production strategy on the new framework of the **Industrial 5.0** will occupy a privileged position in future markets, as well as having a flexible structure to weather possible economic storms. However, they will also have a mission: to show the rest of the world the advantages of technology at a human level, in order to convince us of its benefits.

Marketing and the transition to Industry 5.0

Over several decades, Kotler has taken us through a series of books that have shaped marketing and the branches that flow from it. Marketing 1.0 focuses on the product; Marketing 2.0 on the customer; Marketing 3.0 on the human being; while the use of technologies in Marketing 4.0 is fairly basic, the book introduces new marketing frameworks for serving customers at hybrid (physical and digital) touchpoints. Marketing 5.0, by definition, is the application of technologies that mimic humans to create, communicate, deliver and enhance value.

Marketing 5.0 is about technology for humanity; digitalisation, its pros and cons; generational gaps, artificial intelligence (AI), consumer experience (CX) and its 5 As (aware, appeal, ask, act, advocate). Predictive, contextual, augmented, agile marketing.

Internet users will continue to grow: according to several studies, 90% of the population will have access to the internet by 2030. Therefore, companies must adapt and evolve towards two variants: maximise value creation for the present and start positioning brands for the future of this industrial revolution 5.0.

Kotler points out that the most important thing now is agility: decisions must be made quickly, otherwise delays will significantly affect results.

In this new era, several generations live together, but not all of them know how to adapt easily (imagine your grandfather talking to Alexa). Marketing analyses the "Swich on/off" behaviour of users, a methodology that measures how audiences move between offline and online in their daily lives.

The digitisation of the industrial revolution 5.0 brings with it well-founded fears about its use, application and the impact it may have on society, considering that we have historical precedents such as the industrial revolution, where machines came to replace some jobs.

Before we dive headlong into digitalisation, Marketing 5.0 suggests that a symbiosis between technology and humans is necessary, based on understanding the role of each one, so as not to generate erroneous expectations and assign the correct tasks to each party.

Understanding this point will be crucial to succeed in the digital world and lose the fear of the technological implementation of the industrial revolution 5.0. Although marketing 5.0 may seem very technical, without finding the right balance between technology and human beings we can already predict a game over. Knowing what role each one occupies and operating accordingly is essential for the digitalisation of the 5.0 industrial revolution. Brands are looking for new consumer experiences, creating new relationships. We need to understand the stages of the consumer: when their interest in solving a need arises, meeting it, thinking about buying a product, acquiring it and having an experience with it. In this way we will understand their emotions at each step of the process.

Marketing 5.0 provides us with a much more personalised service, in line with the philosophy of the 5.0 industrial revolution. Through the data received about the customer, we know at all times what they like, what they want and what message will make them fall into the temptation of our company.

This new marketing concept gives us more advanced tools to analyse the state of our brand in a comprehensive way. Technology helps us to make execution much more precise, practical and at a lower cost.

4.6 Final thoughts

Consumers are increasingly seeking personalized products, and while robots excel in the creation of standardized items, they cannot provide that intangible spark of creativity found within people. The human touch is vital to the manufacturing process when creating personalized items. Humans vs Machines is a beloved fictional trope, but it's a false dichotomy. In reality, a human operator guiding the actions of a machine performs most efficiently with the least errors.

As with all industrial revolutions, Industry 5.0 will create new jobs that sound impressively futuristic. One example is the Chief Robotics Officer. This professional specializes in the interaction of machines and operators, as well as having expertise in robotics and artificial intelligence.

Employee training will also advance as virtual education becomes more widely available. Companies can save money since they do not have to halt work to train their personnel. A plethora of career opportunities related to the interactions between robotic systems and artificial intelligence, among other technologies, are also anticipated. You probably won't be able to get George Jetson's gig, just pushing one button all day, but we're at least headed in that general direction.

Even though it seems like we just got to Industry 4.0, and indeed many companies are still transitioning, it's critical to keep an eye on the future. The manufacturing sector is not static, and new technologies are continuously propelling it ahead. Just as Industry 4.0 technology required companies to step out of their comfort zone, adapting to Industry 5.0 will require an open mind and a readiness to embrace the changing role of the production worker.

What never changes is consumer demand for high-quality goods, and the need for manufacturers who can fulfil those desires. Industry 5.0 leans on technology to boost efficiency and save money on operations, but it's human cognition that will separate it from previous era of automation. When it all works in harmony, personalized, high-quality products can be made faster and cheaper than ever before.

Not to get too sappy, but it's not all just about revenue and efficiency. Technology works for people, and it should improve our lives. That's why Industry 5.0 is not only a technology-driven revolution but also a value-driven movement. Ideally, it will push the manufacturing sector into a future where respect and consideration for the environment and the inherent value of human beings will be core values that guide the market.

5. Education and training

5.1 Introduction

Education is seen as a necessity, and the cornerstone for every country's reforms. In reaction to developments in both culture and business, education evolves, creating the valuable intellectual resources that businesses need in the future to succeed.

The education in Industry 4.0 was more technological oriented i.e., minimizing human involvement and giving priority to machines but with I5.0 the motive is to create a synergy between autonomous machines and humans. The duo of powerful machines in combination with better-trained specialists will foster an effective, sustainable, and safe production.

Industry 5.0 will also bring in the role of Lead Robotics officer.

This individual specializes in machine-operator interaction, and also has experience in fields such as robotics and AI. His position in the organization requires making decisions on these variables and this is only possible with the education 5.0 skills i.e., fusion of technological and communication and leadership.

Kent and Kopacek[84] related the traditional education with Industry 5.0 by asking the questions such as whether the traditional education is enough to educate a worker? Or is there a need of improved education system?

Industry 4.0 had in fact prioritized automating processes and reducing the need for human intervention, resulting in machines took over many tasks previously performed by humans. Industry 5.0 seeks now to create a balance between human and machine involvement in order to maximize the benefits of their interaction [85].

Industry 5.0 is a movement focused on revolutionizing the global industrial landscape with the goal of prioritizing human well-being and sustainability. It seeks to use innovative solutions to not only create employment and economic growth, but also to promote the overall prosperity and sustainability of humanity as a whole[86].

In education, Industry 5.0 refers to the cooperation between technologies and educators and students to enhance the efficiency and effectiveness of teaching and learning. Industry 5.0 technologies have the potential to revolutionize the way students learn, and teachers teach.

Industry 5.0 brings therefore a number of applications.

One interesting application of Industry 5.0 is the use of virtual and augmented reality for training, design, and maintenance, as well as the integration of renewable energy sources into industrial operations.

Even educational technologies play a vital role in education by providing students with access to a wide range of learning resources, making it easier for educators to personalize the learning experience, and providing students with access to advanced learning tools. These technologies can revolutionize students' learning and lead to a more efficient, personalized, and effective education system.

Another application of Industry 5.0 in education is the use of smart classrooms and learning environments. These classrooms utilize technologies, such as smart boards, interactive displays, and virtual reality, to enhance the learning experience. For example, students can use virtual reality simulations to learn hands-on skills, such as manufacturing operations, surgical procedures, or automotive repair [87].

One more application of Industry 5.0 in education is the use of artificial intelligence and machine learning to personalize the learning experience for each student. This can be made through the use of adaptive learning software, which adjusts the curriculum and difficulty level based on a student's performance and needs. This allows students to learn at their own pace and ensures that they are receiving the best possible education.

Big data analytics is also being utilized in education to track student progress and identify areas where they may need additional support. This data can be used by teachers to tailor their lesson plans and instruction methods to better meet the needs of their students. In addition, the use of predictive analytics to identify students at risk of falling behind or dropping out, allowing educators to intervene and provide additional support.

Additionally, the implementation of AI-based intelligent scheduling systems enables the creation of personalized class schedules for each student based on their academic needs and interests. The use of machine learning algorithms can also help analyse student data and identify patterns and trends that can help educators tailor their teaching strategies.

It is no coincidence that the adaptation of technology to man coincides with the adequate training of the people who use it: the same is true for man-machine interaction, for cognitive calculation, the use of self-learning algorithms and quantum.

The World Manufacturing Forum has identified a top-10 of skills that will be needed in future manufacturing. Surprisingly, only four of them refer to digital skills; the others refer to skills such as creativity, resourcefulness, flexibility, and open-mindedness. Communication is the real deal.

The WMF's Top Ten Skills for the Future of Manufacturing

<p>1 A</p> <p>Digital literacy as a holistic skill to interact with, understand, enable, and even develop new digital manufacturing systems, technologies, applications, and tools</p>	<p>6</p> <p>Inter-cultural and -disciplinary, inclusive, and diversity-oriented mindset to address new challenges arising from a more diverse manufacturing workforce</p>
<p>2</p> <p>Ability to use and design new AI and data analytics solutions while critically interpreting results</p>	<p>7</p> <p>Cybersecurity, privacy, and data/information mindfulness to reflect the rapidly increasing digital footprint of the manufacturing value chain</p>
<p>3</p> <p>Creative problem solving in times of abundant data and technological opportunities in smart manufacturing systems</p>	<p>8</p> <p>Ability to handle increasing complexity of multiple requirements and simultaneous tasks</p>
<p>4</p> <p>A strong entrepreneurial mindset including proactiveness and the ability to think outside the box</p>	<p>9</p> <p>Effective communication skills with humans, IT, and AI systems through different platforms and technologies</p>
<p>5</p> <p>Ability to work physically and psychologically safely and effectively with new technologies</p>	<p>10</p> <p>Open-mindedness towards constant change, and transformation skills that constantly question the status quo and initiate knowledge transfer from other domains</p>

Transferring learning into Industry 5.0 is currently in a nascent stage.

A review of the existing literature on the topic of Industry 5.0 and education has revealed several potential areas for research. The goal is to create a more holistic and human-centred approach to learning and skill development that leverages the power of technology to enhance, rather than replace, human capabilities.

Some of the research themes and their related research questions are listed in Table 2.

Table 2: Research themes and their related research questions.

Themes	Research questions
Pedagogical approaches	<ul style="list-style-type: none"> • How can Industry 5.0 technologies, such as virtual and augmented reality, be used to create immersive and interactive learning experiences? • What are the most effective ways to integrate Industry 5.0 technologies, such as Artificial Intelligence, into the classroom and curriculum? • What are the effects of Industry 5.0 technologies on students' critical thinking and problem-solving skills? • How do Industry 5.0 technology-enhanced pedagogical approaches impact students' motivation and engagement? • How does integrating Industry 5.0 technologies in pedagogy change the role of a teacher in the classroom?
Technology adoption	<ul style="list-style-type: none"> • What factors influence the adoption of Industry 5.0 technologies in education? • How do teacher training and leadership support impact the implementation of Industry 5.0 technologies in the classroom? • How does the availability of resources impact the implementation of Industry 5.0 technologies in education? • How do economic conditions affect the implementation of Industry 5.0 in education? • How does the cost of Industry 5.0 technologies impact their implementation in educational institutions? • What is the return on investment for Industry 5.0 technologies in education? • How do societal expectations and cultural norms affect the implementation and success of Industry 5.0 in education? • How do technological expectations impact the implementation and success of Industry 5.0 in education? • What are the perceptions of students and teachers towards Industry 5.0 in education? • How do organizational and institutional policies impact the implementation and success of Industry 5.0 in education? • How do leadership and governance impact the implementation of Industry 5.0 in education? • How do regulations and standards impact the implementation of Industry 5.0 in education? • What are the ethical considerations for implementing Industry 5.0 technologies in education? • How do data privacy and security impact the implementation of Industry 5.0 in education?

Technology integration and learning performance	<ul style="list-style-type: none"> • How does using Industry 5.0 technologies for assessment impact student learning and performance? • What is the impact of Industry 5.0-based online learning platforms on student engagement and motivation? • How does integrating Industry 5.0 technologies change how students' access and interact with educational content? • How can Industry 5.0-based technologies support different learning styles and adapt to students' needs? • Does the use of digital tools for assessment improve student performance in all subject areas? • How can Industry 5.0 technologies support collaborative learning, and what is the impact on learning performance? • How can Industry 5.0 technologies be used to create realistic simulations and gamified learning experiences, and what is the impact on learning performance? • How Industry 5.0 improves students' learning outcomes? • How does using Industry 5.0 technologies such as data analytics improve student performance for under-served populations?
Social and emotional development	<ul style="list-style-type: none"> • How does integrating Industry 5.0 technologies in learning environments impact students' motivation, self-esteem, and emotional intelligence? • What are the most effective ways to promote social and emotional development using Industry 5.0 technologies in learning environments? • How can Industry 5.0 technologies be used to support the development of students' empathy, emotional regulation, and social skills? • How does the integration of Industry 5.0 technologies affect the formation of a student's identity and sense of belonging to a group? • How can Industry 5.0 technologies foster a sense of community in an online learning environment?
Sustainability	<ul style="list-style-type: none"> • How can Industry 5.0 promote sustainable education by incorporating sustainable values and practices into the curriculum and teaching methods? • How can Industry 5.0 technologies be used to promote sustainable practices in the classroom and throughout the school or institution? • How can Industry 5.0 technologies enhance the accessibility and inclusivity of education? • How can education support sustainable development by preparing students to become responsible citizens and leaders in sustainable practices? • How can Industry 5.0 be used to address environmental and social issues in the context of the local community? • How can education foster a sustainable mindset and behaviour in students by incorporating Industry 5.0 technologies and practices? • Can Industry 5.0 technologies be used to educate and raise awareness on sustainability issues to a broader public? • How does the implementation of Industry 5.0 affect the well-being of students? • In what ways does Industry 5.0 contribute to sustainable education? • How Industry 5.0 makes education more accessible, particularly to disadvantaged students?

Partnerships and collaborations	<ul style="list-style-type: none"> • How can new partnerships and collaborations be established between educators, industry, and other stakeholders? • What are the benefits and challenges of industry-academia partnerships for Industry 5.0 education research? • How can collaborations be formed and maintained between educators, researchers, and policymakers to drive the development and adoption of Industry 5.0 technologies and pedagogical approaches?
Personalized learning	<ul style="list-style-type: none"> • How can Industry 5.0 technologies, such as data analytics, be used to personalize instruction and improve student outcomes? • What are the best practices for personalizing instruction using Industry 5.0 technologies? • How can Industry 5.0 technologies be used to identify and support individualized learning paths for students? • What are the implications of Industry 5.0 technologies for designing and implementing personalized learning in education? • How can Industry 5.0 technologies be used to track student progress and provide real time feedback? • How can Industry 5.0 technologies be used to create personalized learning experiences for students?

The increase in human potential will help promote the updating and requalification of skills, favouring innovation and research in a problem-solving key. Skills, people efficiency and productivity go hand in hand.

5.2 Challenges in Education

While Industry 5.0 brings many potential benefits, it also presents several challenges for the education sector.

One major challenge is the need to prepare students for jobs that do not yet exist.

Industry 5.0 technologies are rapidly evolving, and it is difficult to predict exactly which skills and knowledge will be required in the future. This makes it difficult for educators to prepare students for the job market and ensure they can compete in a rapidly changing economy.

Another challenge is the need to provide students with the necessary digital skills to thrive in an Industry 5.0 world. As more and more jobs become reliant on advanced technologies, it is crucial that students are proficient in areas, such as coding, data analysis, and machine learning. This requires a significant investment in both teacher training and the development of relevant curricula. Additionally, not all students have the same level of access to technology and digital resources, which can create a divide between those who are able to take advantage of Industry 5.0 opportunities and those who are left behind. This is particularly true in developing countries, where access to education and training may be limited.

As intelligent technologies become more sophisticated, there is a risk that they may be used to discriminate against certain groups of people or to perpetuate existing power imbalances. It is important that educators address these ethical issues and ensure that students are aware of the potential risks and responsibilities associated with Industry 5.0 technologies. One of the main challenges of Industry 5.0 in education is the need to adapt teaching and learning methods to accommodate Industry 5.0 technologies. This may require the development of new pedagogical approaches, as well as the integration of technology into the classroom.

It may also require the adoption of new assessment methods to evaluate students' knowledge and skills in this rapidly evolving field.

Another challenge is the need to address ethical concerns related to the use of Industry 5.0 technologies. For example, there are concerns about the potential for AI and robotics to perpetuate biases and perpetuate inequities. There is also a need to consider the potential for these technologies to be used for nefarious purposes, such as surveillance or manipulation.

Another challenge of Industry 5.0 in education is the impact on employment and job security.

As advanced technologies are integrated into the manufacturing process, there is a risk that many jobs will require high-skilled workers to interact efficiently with machines.

This can lead to widespread unemployment and a decline in job security, particularly for workers with low levels of education or training.

By the time Industry 5.0 is fully adopted, the requirement of a skilled workforce will be more as well new technologies will grow, leading to adequate training for both the trainees and the prospective trainers.

Furthermore, organizational excellence can be empowered by the trained workforce.

To be on par with digital competence, many industries would adapt to the newly developing technology, but management might not be understanding it.

The skilled employees and the culture may exploit the management's ignorance.

Furthermore, it will incur considerable training costs from a management perspective if the employees are not forward thinkers (the senior employee may take longer to adapt) and may take time for reengineering.

Moreover, some companies may have inadequate infrastructure to accommodate the new technology. Therefore, these issues must be considered while setting up an open business culture, and sustainable recruitment of skilled employees.

This, in turn, will amend the future business transformations at a faster pace.

Finally, the continuous training for operational workers (human workmanship) will ensure a skilled workforce.

5.3 Digital Training

Training is essential to accompany the change to which all companies are called in this era of digital transformation 5.0. Training structured in all its possible forms.

We need to overcome the perception that online or hybrid learning has only been linked to the COVID emergency, relegating it to a secondary role compared to face-to-face training. This leads to the abandonment of the dichotomies on learning, which separate the digital world from the physical one: in presence/at a distance, physical-digital (hence the neologism phygital), synchronous/asynchronous.

Hybrid learning requires a change of mentality not only in the learner but also in institutional practices, reinforcing the very concept of life long and transforming it into life wide learning, which with renewed methodologies can contribute to participation and inclusion from a of collaboration, also offering a stimulus to explore and deepen new themes, thanks to the almost continuous connection and interaction between learners and trainers.

New forms of learning with hybrid models of digital training integrated with face-to-face training are highlighted in the same European programs: blended learning, MOOC, ILA, micro-credentials, augmented reality technologies in experiential training, introduction of collaborative methods, mobile learning, virtual tutors, e-learning chatbots. Digital learning is increasingly used in innovative companies, and market trends see a propensity for non-formal learning (courses) integrated with informal learning.

In such an innovative context, intelligent learning environments based on the IoT (Internet of Things) are used, integrated into the work environment through LMS (Learning Management System) platforms: physical environments enriched with context-aware digital devices to improve and accelerate learning, usable both online and offline.

Innovative training models and methods are gaining ground, not only in terms of delivery methods, which best combine with the urgent need for reskilling and upskilling imposed by innovation, as regards digital skills and soft skills.

Learning tends to be integrated into daily work (training that can be used quickly and when needed), delivered through short and targeted modules that are easy to understand (micro credentials).

The variety of new tools and methodologies for continuous training in particular includes among the most used currently, fully digital platforms, tools and resources, including webinars, online courses, videos, podcasts, online educational materials and use of social media, alongside forms of blended learning that also combine learning in a physical environment with classroom training, coaching, events, seminars.

Instead, we talk about phygital learning when digital activities are integrated with face-to-face sessions to provide a more engaging and effective learning experience (brainstorming, challenges) by bringing the character of gamification also through apps on mobile devices. It being understood that these types of training

require at least basic digital skills and at least a medium level of other skills (as well as a digital and growth mindset).

There are many digital tools available in training; a brief list of some of them that stand out (though not in any specific order) is given below:

Table 3: Digital tools available in training.

<p>Microlearning</p> <ul style="list-style-type: none"> • This represents short, bite-sized training content that can be consumed quickly and easily. • It can deliver just-in-time training on specific topics, making learning more accessible and convenient for employees. 	<p>Video Conferencing</p> <ul style="list-style-type: none"> • It can be used for virtual classroom training, online coaching, and remote team collaboration. • It enables remote employees to participate in live training sessions, interact with trainers and colleagues, and ask real-time questions.
<p>Mobile Learning</p> <ul style="list-style-type: none"> • It enables employees to access training content on their mobile devices anytime and anywhere. • It can be used for on-the-job training, compliance training, and other types of training. 	<p>Virtual and Augmented Reality</p> <ul style="list-style-type: none"> • It can provide immersive and interactive training experiences for employees. • It can simulate real-life scenarios and environments, enabling employees to practice skills and scenarios in a safe and controlled environment.
<p>Social Learning</p> <ul style="list-style-type: none"> • It enables learners to interact and collaborate, share knowledge, and build communities of practice. • Its standard tools are forums, chat groups, and social media platforms. 	<p>Learning Management System (LMS)</p> <ul style="list-style-type: none"> • It enables organizations to manage, deliver, and track employee training programs. • It can be used to provide online training resources, assessments, and reporting features to monitor employee progress and completion.
<p>Personalization</p> <ul style="list-style-type: none"> • It can tailor training content to individual learners' needs and preferences. • It can help employees to learn more efficiently and effectively, leading to better learning outcomes. 	<p>Analytics and Reporting</p> <ul style="list-style-type: none"> • It can provide insights into training effectiveness, learner engagement, and program completion rates. • It can help organizations to optimize training programs and improve learning outcomes.
<p>Gamification</p> <ul style="list-style-type: none"> • It uses game elements such as points, badges, and leader boards to motivate and engage learners. • It can make training programs fun and engaging, leading to better learning outcomes. 	<p>AI and Machine Learning</p> <ul style="list-style-type: none"> • It can automate routine tasks, provide personalized recommendations, and improve training content. • It can help organizations to create more efficient and effective training programs.

And how can we fail to address the relationship between Industry 5.0 and the Metaverse?

Experts already see points of contact, territories where the two realities can meet and offer benefits.

Definitely in employee training.

Through the meta-representation of the real work environment, using mixed or virtual reality, companies will be able to create virtual environments that faithfully represent the real conditions in which human resources will have to operate. This speeds up training times and also improves people's safety in case of hazardous environmental conditions.

A similar argument applies to machines: having the possibility of implementing a simulation of the behaviour of a machine through the digital twin, for example, allows companies to speed up development and avoid unforeseen problems during production.

The Metaverse offers the possibility of operating remotely without the physical movement of the expert; as happens in remote surgery, for example.

Another possibility comes from being able to collaborate with other subjects in the design and production, without suffering physical limits.

A manufacturing company, for example, will be able to use third-party services for the design of the product and then produce it where it is needed through industrial 3D printing.

5.4 Augmented Reality and Virtual Reality

The incorporation of VR and AR into learning has created an environment where learners can have a hands-on learning experience.

The technologies facilitate learning by doing, even in cases where the approach has been impossible. The market growth of these technologies is impressive.

The value of AR in education is expected to reach \$5.3 billion by 2023. At the same time, VR in education is predicted to grow to \$640 million.

** What is AR?*

AR or augmented reality is the incorporation of digital information in a video or user environment in real-time. You can use the technology to superimpose sound, videos, images, animations, and more to create a holographic effect.

** What is VR?*

VR or virtual reality is a technology that creates a virtual environment, putting the user inside the experience. Using VR headsets, viewers can interact and manipulate a 3D world for an experience closer to reality.

The use of AR and VR in training has some clear benefits.

1. Providing training in a safe and affordable manner

Some industries need to train their employees in the processes and operations before they assume full responsibility. For instance, employees working in manufacturing units need to know how to operate machines properly on the site. Unless they get a good knowledge of things, they cannot be allowed to take over.

VR and AR can be used to make simulations where training can be safe and free of consequences. Employers can create an exact simulation of their operations with the equipment they use.

New employees can then gain expertise through the simulation and experiment to their heart's content. Even if they make mistakes, the consequences will only be felt in the virtual world of the simulation.

VR simulations put the learner inside the virtual environment.

They do not use the mouse or keyboard to navigate or interact. They can find themselves inside a 3D production line where they can try their skills in real time. VR simulations create the feel of navigating the real world effectively for a better practical learning.

2. A better way of practicing skills

Practicing the skills is the best way to sharpen them. According to studies, we retain much more information when we combine our learning with “doing.” In fact, hands-on practice is the best way to retain information compared to discussions, lectures, reading, or even audio-visual learning. It has a retention rate of 75% compared to lectures with 5% retention capabilities.

3. Developing Soft Skills and expertise

VR and AR can help enterprises develop their employees' soft skills and expertise. Walmart, for example, has been using VR to train its employees to handle customers better. The retail giant even used VR to get employees familiar with dealing with Black Friday customers. Such opportunities help enterprises get employees ready to provide increased customer satisfaction.

Employers can create VR simulations for specific situations the employees are likely to encounter. This makes the employees more comfortable in the actual situations and enables them to provide better service.

4. Enhance the effectiveness of learning/training materials

Employers can develop solutions where pointing your phone camera at a specific text of a training manual leads to additional materials or resources popping up on the users' screen. This technique can be used by enterprises to train employees about certain products, services, machineries, or solutions.

Research also shows VR teaching to be more effective than traditional methods. According to a study, the VR/AR learners had a recall rate of 80% even after 1-year of training. Traditional learning, on the other hand, has a recall rate of only 20% after 1-week.

5. Helping employees develop Technical Skills

VR and AR are ideal for developing soft skills and practice-based learning. However, the same technologies can also help develop technical skills.

The healthcare industry has already started using VR to train doctors and nurses. In one study by Yale University, the VR learners performed surgeries 29% faster and with 6-times less mistakes than the traditional learning group.

The construction industry, too, uses VR and AR for safety training. A study evaluated the effectiveness of immersive learning technologies for safety training. One group received training via VR simulation, and the other used traditional methods. The researchers then tested both groups after training. And one month later, interestingly, the VR group outperformed the other group at the evaluations.

There is no doubt about the effectiveness of using virtual reality in corporate training. That's why many enterprises are deciding to invest in immersive learning involving VR and AR.

6. The best way for Gamification

Gamification has been used for a while to train and onboard employees.

The approach helps employees learn better and show an increased success rate. VR and AR can now take gamification to a completely new level.

Enterprises can now use VR to develop advanced gamification techniques for improved learning. The process is perfect for getting your employees on board and cutting the tiresome process in half. You can even present the best of your company and develop a highly engaging learning experience.

Use of AR and VR has also some disadvantages:

- **Cost:** Start-up costs for augmented reality training programs can be higher than alternatives. Between the hardware, designing, programming, etc. it may be daunting.
- **Technology Development:** We are all excited to start using augmented reality but think about what the future holds! Newer hardware, upgrade capabilities and brand-new accessories. While this is exciting to imagine, it also means that you may have to refresh your program to stay current.

- **Development Time:** Once you decide to integrate augmented reality into your training program, you need to work with designers and developers to put your plan into place. Make sure you build this into your implementation timeline.

5.5 Artificial Intelligence

The AI market will grow to a \$190 billion industry by 2025, according to research firm Markets and Markets. AI has become almost omnipresent in our lives. In fact, some people are even scared of a complete AI win over humans!

While that is certainly an exaggeration, we have nonetheless weaved AI into our daily lives and activities. Even a simple search on Google uses AI to provide with the most accurate results.

AI has been beneficial in a wide range of industries for things such as optimizing logistics, detecting fraud, conducting research, providing translations, and many other tasks. There's hardly a field that has not benefited from AI.

In the education sector, AI is being utilized at all levels, not only in teaching but in other systems that greatly influence academia. It is also widely used by enterprises for employee training. A lot of enterprises have already incorporated AI in their learning strategy.

Why is AI Important in learning and training?

AI, or artificial intelligence, is the computer system simulation of human intelligence processes. In learning and training, AI can enhance and augment learners' educational experiences.

Here's how AI contributes to learning and training:

- **Personalized learning.** AI enables personalized learning experiences for each learner. This can be done by analysing the learner's performance and adapting the curriculum or content to their needs and preferences.
- **Intelligent tutoring systems.** AI-powered tutoring systems can provide learners personalized feedback and guidance as they work through the curriculum. These systems can also analyse learners' performance and adapt the instruction to their needs.
- **Automated content creation.** AI can create educational content, such as videos, quizzes, and other interactive materials. This can save time and resources for educators and trainers.
- **Adaptive testing:** AI can create adaptive tests that adjust the difficulty of the questions based on the learner's performance. This can provide a more accurate assessment of the learner's knowledge and skills.
- **Chatbots and virtual assistants:** AI-powered chatbots and virtual assistants can provide learners with 24/7 support, answering their questions and providing guidance on the material.

- Predictive analytics: AI can predict student performance, identify at-risk students, and provide personalized interventions that can help them improve.

AI in learning and training is a fast-growing field, and new ways of using AI in education are constantly emerging.

The goal of using AI in education is to enhance the learning experience, improve the effectiveness of instruction, and provide learners with more personalized and efficient education.

What is the Role of Artificial Intelligence in learning and training?

1. Identifying knowledge gaps

Most enterprise learning strategies depend on holistic teaching. What it means is, they have the same course materials for all employees. However, not all employees are the same. Some may already have a skill that the job needs. So, forcing them to learn what they already know is not a very effective strategy. AI has the capability to analyse huge data sets and derive conclusions using technologies like machine learning and predictive analysis. AI can also create learner profiles combining disparate data sources, something that will take days if done manually. It can successfully identify the skills missing in the employees, automatically, in a short time.

In fact, this concept is already in use. Popular online training providers can use AI to measure learner performance, skills, and knowledge gaps in an organization. Once the gap is identified, the team can work on adapting their training approach to meet the knowledge gap. This makes learning more effective and doesn't waste crucial employee hours.

2. Suggest the most appropriate content

AI can identify knowledge gaps and then automatically scan for the most appropriate content for the learner. All of us know how that works as we have all used Google to search for information.

Just like Google, AI can scan the internet, LMS, the proprietary content, and other sources to auto-suggest the most relevant content. This approach saves learners' time as they don't have to manually go through multiple pages of search results for hours.

3. Creation of digital content

Creating educational content is time-consuming and challenging. For this reason, most enterprises out-source their content creation at a huge cost. AI can come in here and help organizations save time and cost. We discussed how AI can source information snippets and digital resources from the internet and other connected platforms. The same technology can also consolidate them and present them in an easy-to-understand manner.

AI, through natural language processing, can even convert videos into texts, e.g., converting whole podcasts, webinars, and lectures into written words without any effort. It's the same way by which YouTube provides automatic subtitles in videos.

4. Personalize learning according to the student

AI can personalize learning according to the pace, age, gender, and demographics of the learner. It can release materials to the employee gradually as s/he finishes a chapter or a module.

For example, you want to train an experienced employee in customer management. AI can automatically scan the employee's skills and skip the basic training materials to suggest advanced resources. The technology is even fit to align learning with the employee's learning style. Research has shown that each of us learn in a different style. Men learn better in some ways, while females have their own learning styles. Older adults, again, have a preferred way of learning that is not very effective in the case of youngsters. AI can track and identify employee learning styles, and then optimize the learning experience for the best results. Personalized learning makes way for greater retention, higher recall, and improved learning.

5. AI as a 24/7 Digital Tutor

AI eliminates the need for a human trainer to some extent. Employees may have many questions while they are undergoing training or taking a new course. Most of these queries are common and standard for all learners. In traditional approaches, the employees would have to wait for the trainer to resolve their queries. This means they have to wait for the availability of the trainer.

AI can help address these queries and even provide accurate answers. Enterprises can use chatbots based on AI to help learners get answers to the most common questions. The whole process is carried out in the form of human conversation, just as you chat with a customer care representative.

6. Seamless assessments and instant feedback

Enterprises will not need human efforts for the assessment of learning. AI-driven tools can gather information, evaluate performance, check answer sheets, and provide accurate results. Employees can get feedback instantly and get to know how they performed. AI can be used to deliver any type of assessment as long as it's digital. It's possible to develop a range of assessment techniques and deliver them to your employees. Additionally, AI can even help personalize assessments. Most tests or quizzes are developed based on a 'one-size-fits-all' approach. They don't consider IQ, skills, or other such factors.

Using AI, employees can take tests based on their capabilities, skills, and level of learning. This creates a much more accurate system of performance evaluation and eliminates situations where some find the test too hard, and others find it too easy.

7. Developing crucial insights

AI can mine LMS data, and employee performance, collect feedback, and make way for a range of analytics. Enterprises can use the data to form insights into their learning and development. They can find out the effectiveness of courses, areas of improvement, and crucial trends and patterns.

The insight can help you refine your content, courses, and training strategy for better results. AI can do the work of collecting data continuously so that you can always make informed business decisions.

AI is one of the most promising technologies that can revolutionize learning and development. Many enterprises have already stepped in to make the most of AI and dedicated due investments. AI is ideal for making learning fast and increase the rate of completion. Not only can it enhance learning, but also improve efficiency, engagement, interactivity, and recall.

5.6 Smart human-computer interfaces

We interact with computers like it is oxygen.

At one point, not that long ago, we did not interact with computers daily; however, humans are quick to invent and quick to adapt to new systems that improve their lives.

The computer has been a dominant force in our day-to-day existence, and the ways we interact with computers have changed over time. Computers and software are fundamentally supported by the ways humans can interact with each other in the world.

Humans, computers, and artificial intelligence should be leaned on for what they do best.

INTERACTION DESIGN PARADIGMS

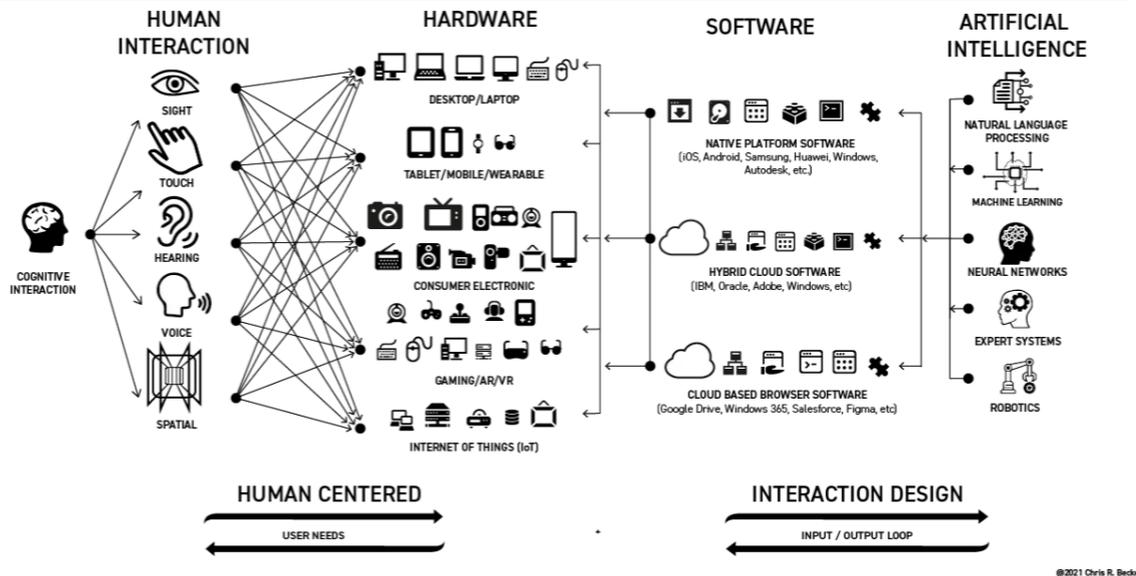


Figure 14: Human-computer interactions Source: uxdesign.cc

Allow humans to focus on creativity, design, communication, and value.

Allow computers to focus on computation, processes, and data collections.

Allow AI to focus on mining the data and making processes more efficient.

Focusing on these and many other aspects will allow the vast set of skilled humans who build these systems to be more creative. Our complex systems can hopefully be designed to free up skilled humans to tackle even more difficult problems.

From management of production to climate modelling, our ability to integrate and utilize computer paradigms will continue to support and require highly skilled professionals as the engine that drives its success and ability to continue to change our world.

In this field, Human-computer interaction (HCI) is defined as the field of study that focuses on optimizing how users and computers interact by designing interactive computer interfaces that satisfy users' needs.

HCI is not only about providing better communication between users and computers but also about factoring in the context and environment in which the system is accessed.

For example, while designing a smartphone app, designers need to evaluate how the app will visually appear in different lighting conditions (during day or night) or how it will perform when there is a poor network connection. Such aspects can have a significant impact on the end-user experience.

The interface is the crucial HCI component that can enhance the overall user interaction experience.

Various interface-related aspects must be considered, such as interaction type (touch, click, gesture, or voice), screen resolution, display size, or even colour contrast.

Users can adjust these depending on the user's needs and requirements.

For example, consider a user visiting a website on a smartphone. In such a case, the mobile version of the website should only display important information that allows the user to navigate through the site easily. Moreover, the text size should be appropriately adjusted so that the user is in a position to read it on the mobile device. Such design optimization boosts user experience as it makes them feel comfortable while accessing the site on a mobile phone.

Today, human-computer interfaces are turning into tools for conveying ever more natural ways of communicating between humans and machines. We are fully on the path towards full immersion in the context, a world in which reality will be superimposed and mixed with the digital one. Advances in immersive technologies and neuroscience suggest that a world where humans are fully connected to computers may not be that far off. Already today, the latest developments, particularly in science and medicine, show that it is possible to connect the human brain to computers for thought control or even for human interaction, whether via headphones or brain implants. Many companies are already working on mind-control headsets, thought transmission communication or brain chips.

For enterprises, basic and advanced HCI technologies represent the path to a world of work, training and production characterized by a myriad of opportunities.

In the context of Industry 5.0 and digitization, more generally, the world of work is radically transforming. For example, the growing variability and customization of products in modern industrial production poses new challenges for operators engaged in manual assembly. HCI in the industrial context supports the worker during these production activities, improving his skills, as well as quickly training him in learning a new task or in re-skilling towards different tasks.

Despite the impressive advancement of the enabling technologies of Industry 5.0, which have significantly increased the number of machines capable of operating autonomously, the contribution of the operator remains one of the most significant factors in this new scenario. It is therefore necessary - and fundamental - to support the technological advancement of machinery with advanced HCI systems that support the operator within increasingly complex and heterogeneous production systems, where the interaction between people, software components and mechanical or hardware components must be facilitated and made faster and more fluid.

Within a plant, advanced HMI technologies for augmented or virtual reality represent ways to significantly improve the quality of the activities of operators in production, in terms of times and feedback, and in training, with a view to professional integration or updating.

One of the great challenges that the industry must and will have to face is that of the continuous training of people.

Precisely advanced HCI technologies, to the advantage of training and re-skilling processes, are increasingly widely used: let's think, for example, of an intelligent wearable device, similar to sturdy glasses, of mixed reality designed and built to easily provide workers access to remote experts for explanations and/or checks and train new operators (or re-skilling personnel to be repositioned) more quickly, superimposing an AR environment on the real context with images, drawings and interactive 3D guides.

Using technology to produce continuous learning and support as part of computer applications involves much more in terms of integration and interaction than traditional training. Creating interactivity and building programs that give learners freedom and control over the process requires a new and radically different approach to designing and writing educational materials.

5.7 Methods

In the last 16 years, the use of eLearning technologies by enterprises have grown by 900% and 98% of startups and small businesses are preparing for adoption of eLearning as their full-time learning and development structure.

The reason behind this shift is long-term benefits associated with eLearning methods, such as:

- Reduced costs of training
- Increased revenue
- Improved productivity

And as the adoption increases year on year, there are new technologies contributing to this ever-growing scenario. Let's take a deeper look at each one of them:

1. *Microlearning*

Microlearning includes delivering small chunks of information in short bursts. For example, creating 5-minute or 10-minute videos for a sub-topic.

Why?

The idea behind it is to deliver only one aspect of a larger topic at one time. This makes the sessions more focused and actionable at the same time. If an employee is facing an issue regarding a subtopic X, they can easily find a learning module related to X. They don't have to go through the whole topic again. Since the

delivery of knowledge is short and to-the-point, it is easier for the learner to retain knowledge effectively. Videos, infographics, tests, and small activities form some of the key methods to deploy this technique for any organization.

2. Adaptive Learning

Say you have 150 employees at the workplace, and each employee will have a different format/learning path based on their personal learning preferences. You achieve this by Adaptive learning, where the learning path is personalized according to the needs and learning requirements of an individual.

AI helps the system analyse data related to how the learner grasps concepts and what type of training should be followed by which concept?

This saves the learners' time from skimming through the topics they already know and get started with the topics they need to learn.

3. Game-based Learning

If the learning process is dull, employees will not be able to gain the skills and knowledge to perform in real-life scenarios. Learning no longer means memorization or passing of information from the teacher to the taught. Learning, and more specifically in the enterprise context, is more about gaining first-hand experience, knowledge, and skills to solve real-life problems. And game-based learning helps to achieve just that.

So how do we learn through games? Here, it is important to point out that game-based learning is different from games – while games are just for fun and relaxation, game-based learning refers to games that enhance instructional strategy with the aim to increase engagement, motivation, and participation in learning activities.

Game-based learning enables learners to experiment, analyse and progress by trial and error, and along the way, learn what they should do and what they should avoid doing. And as the mind is trained, it deciphers how the new system works and learners are able to climb to the next level of the ladder.

It is also known that games generate happy emotions which lead to the release of pleasure hormones like serotonin and dopamine. Blending this aspect of games with eLearning is a trend which began a few years back and still continues to be a part of corporate training programs.

One more benefit of game-based learning is learner engagement, which leads to a higher retention rate, and it adds value to the performance of the employees. Any successful game-based learning program will include following:

- Helps to solve problems, build hypothesis, and develop strategies.
- Keep people interested.
- Challenge users but keep them satisfied with growing levels.

- Personalized game-based paths.
- Capability to communicate or interact with other players.
- Shouldn't be too easy or too difficult.

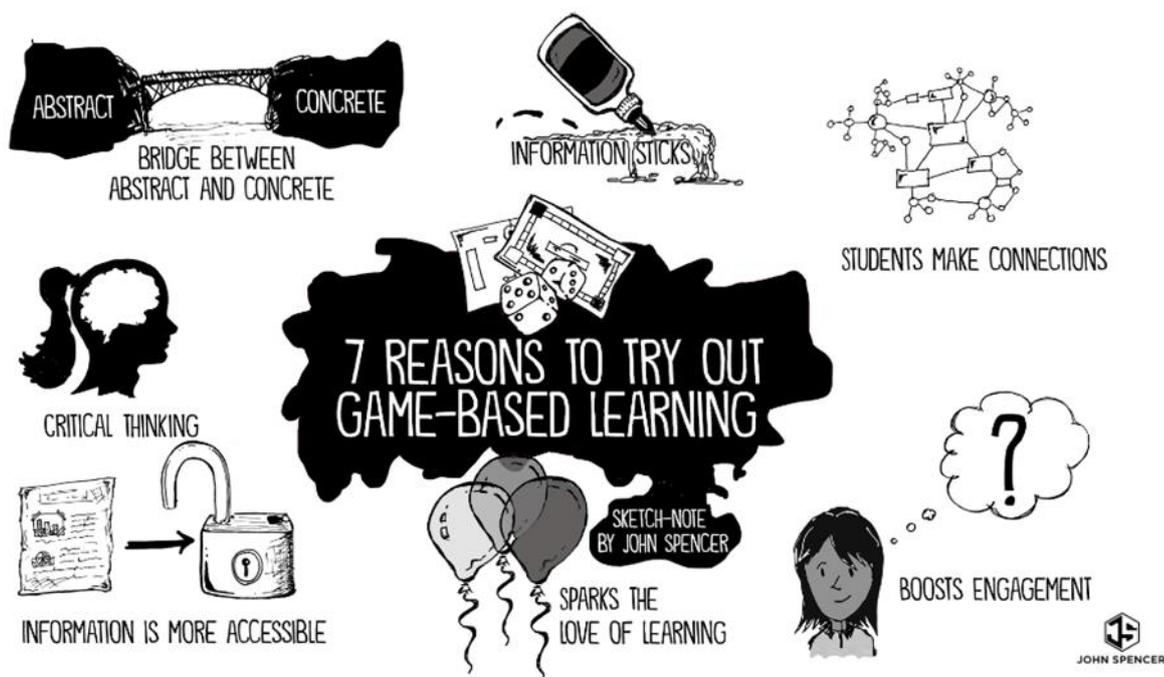


Figure 15: Reasons to try out game-based learning. Source: spencerauthor.com

5.8 Conclusions

Industry 5.0 offers a clear path to a more resilient, sustainable, and human-centric industry and society.

Industry 5.0 is a concept that has been designed to harmonize the working space and efficiency of humans and machines in a consistent manner.

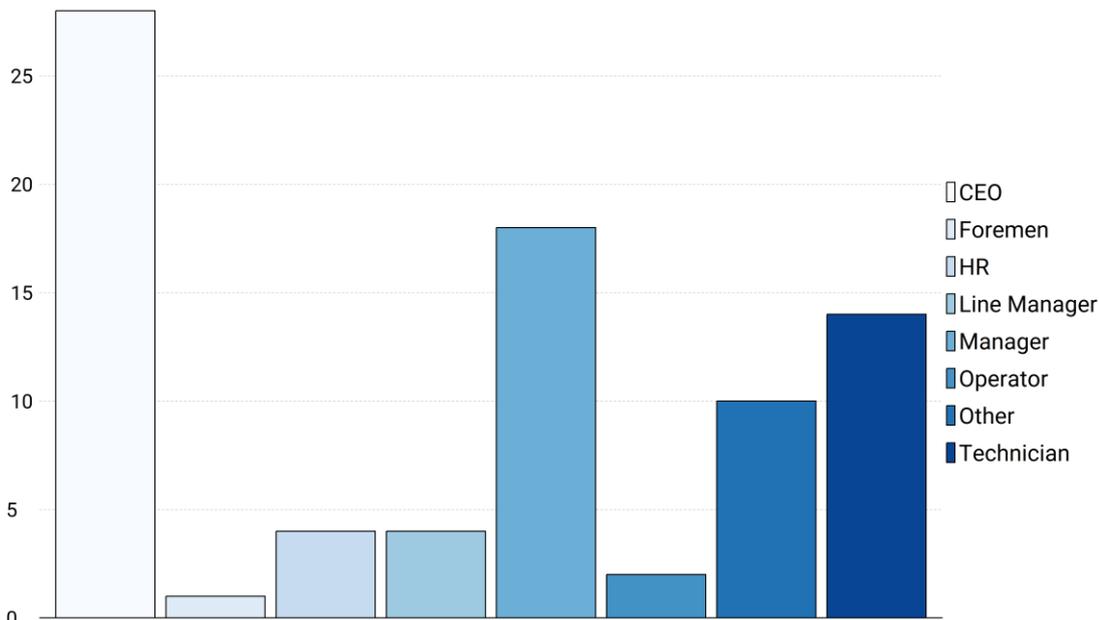
Enabled by a variety of emerging applications and supporting technologies, Industry 5.0 is expected to increase manufacturing production and customer satisfaction, but above all the value of the human being in the company, educated and trained with adequate skills and knowledge.

6. i5.0 in the footwear industry – questionnaire results

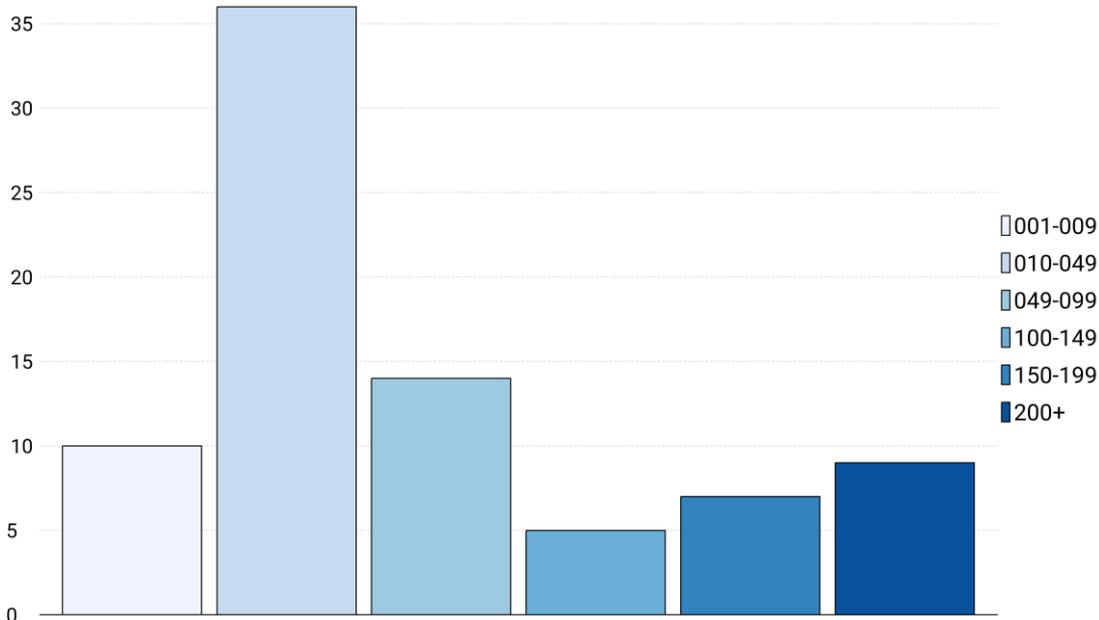
Results from the focus group and the questionnaire show an interest in the subject of i5.0. Companies show interest in the topics here presented and are aware of some of the potentialities of industry 5.0, even when they do not totally understand the impacts or the use of enabling technologies. Questions were divided by topics, including the main pillars of i5.0. At the same time, some of the questions allowed to characterize the person and/or the companies answering the questionnaire. The questionnaire can be found at <https://forms.office.com/e/MX0HNwGGfe>, and the results are presented below.

Data from respondents

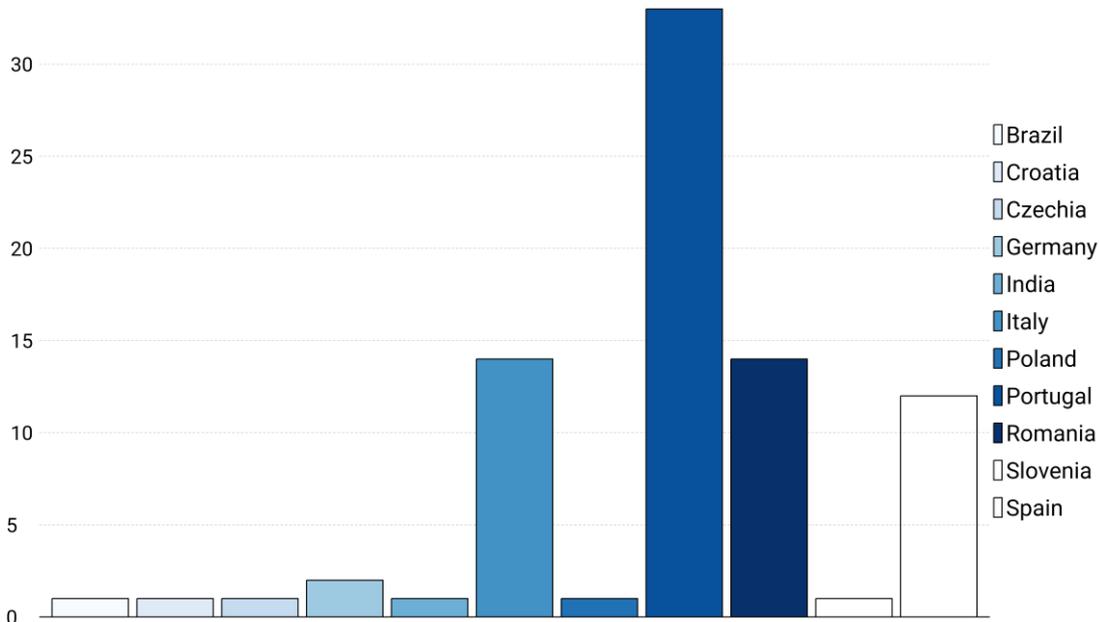
Role in the company



Company Size



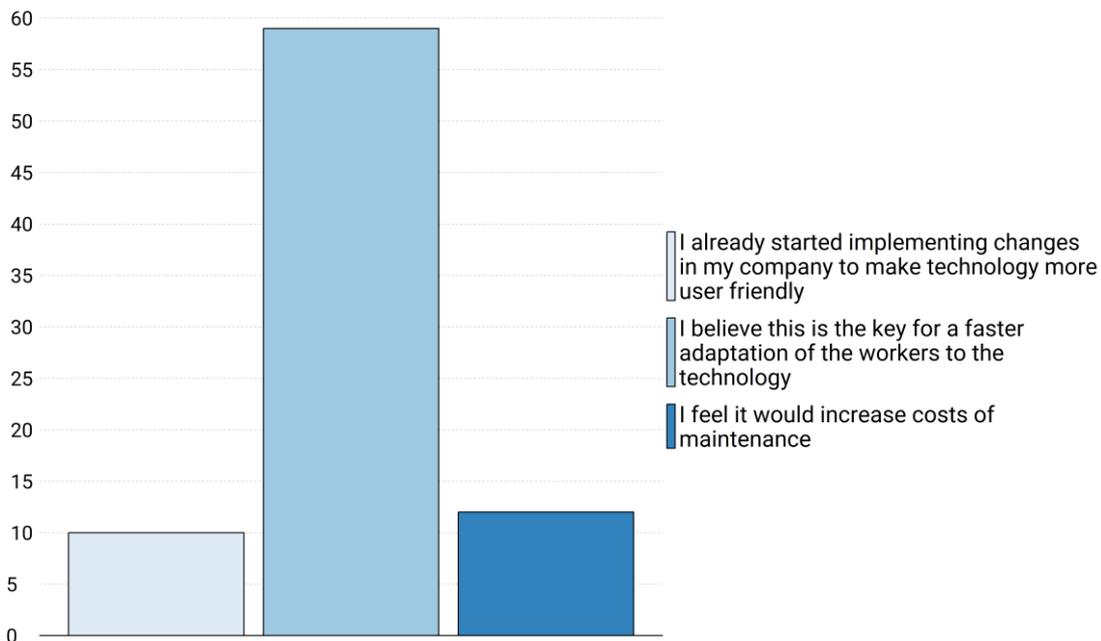
Country



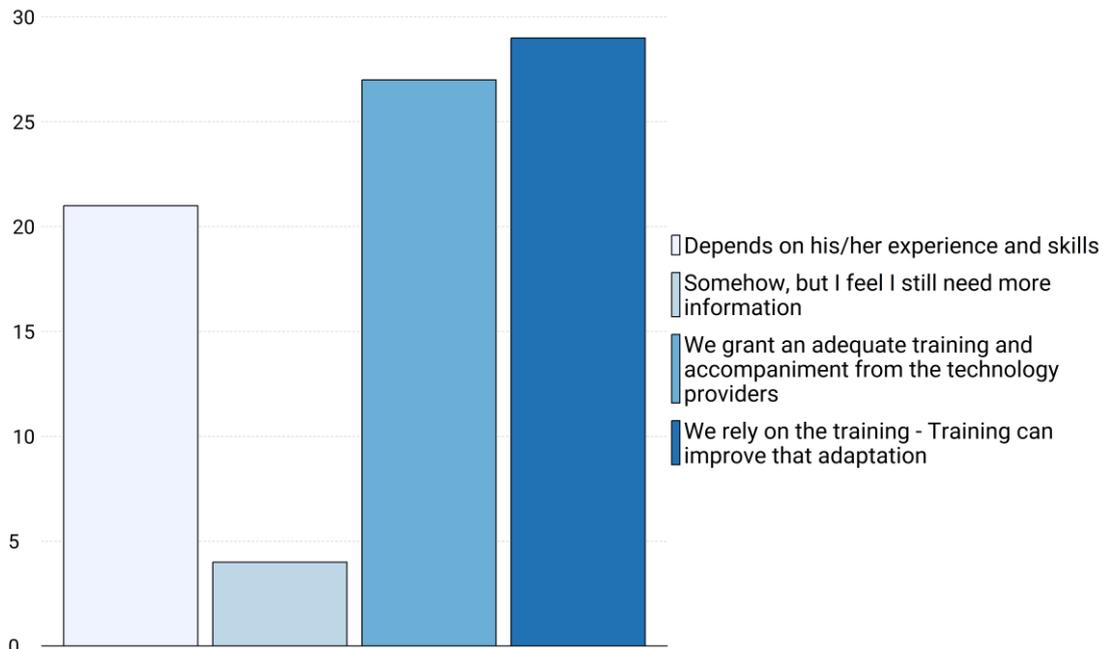
Human Centric

- Human needs and interests at the heart of the production process.
- Technologies helping and adapting to workers, e.g.: guidance and training.

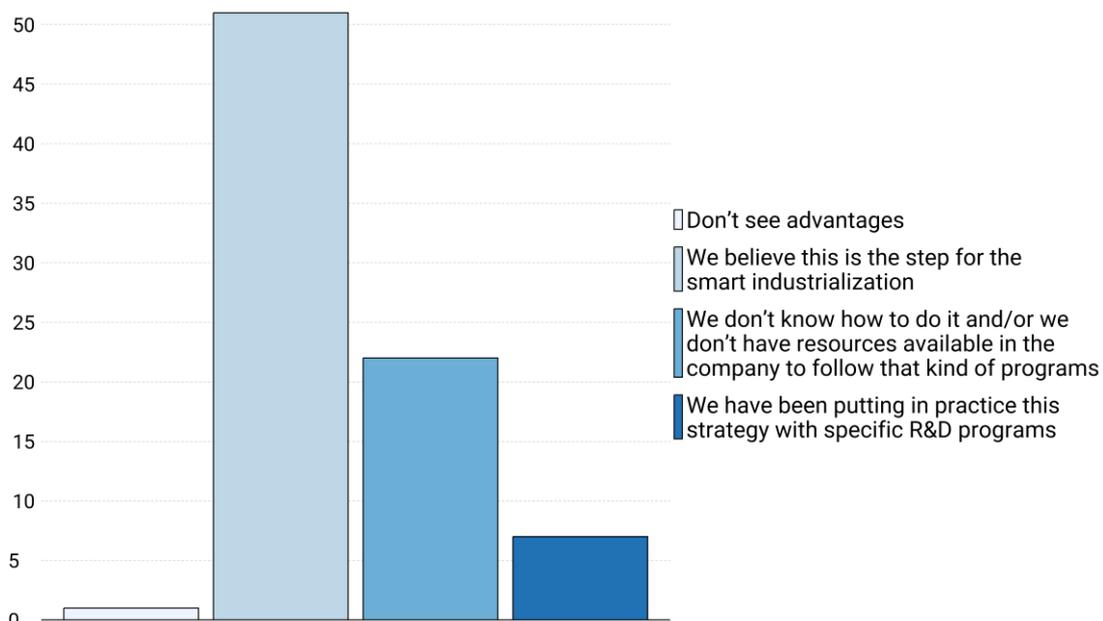
How do you feel about technology adapting to users instead of users adapting to technology?



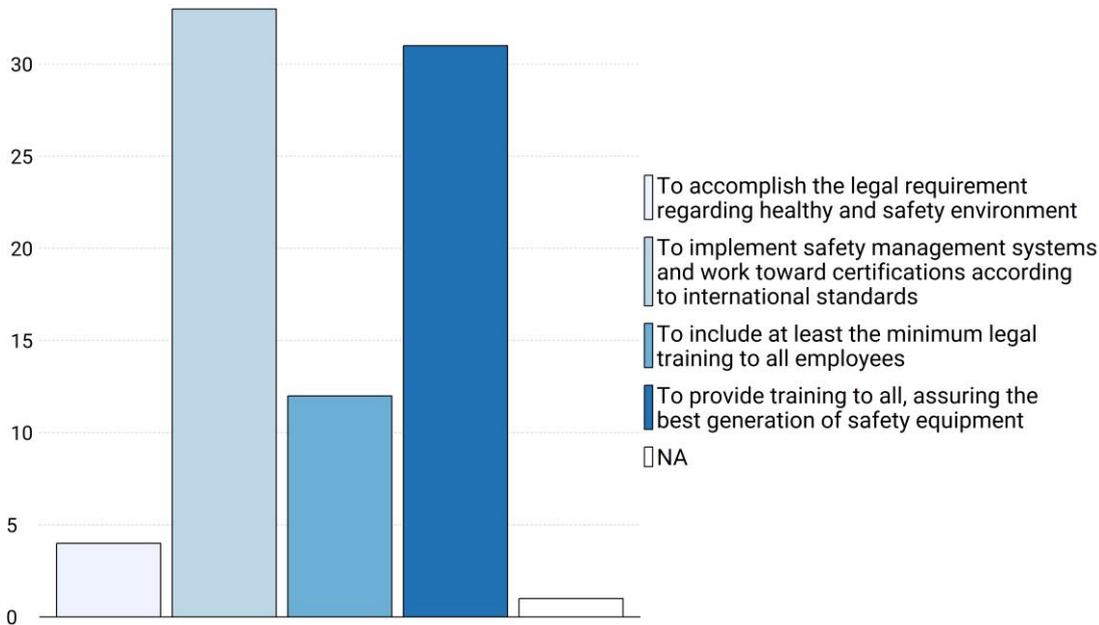
How hard is for a worker to adapt to a new machine acquired to the shopfloor?



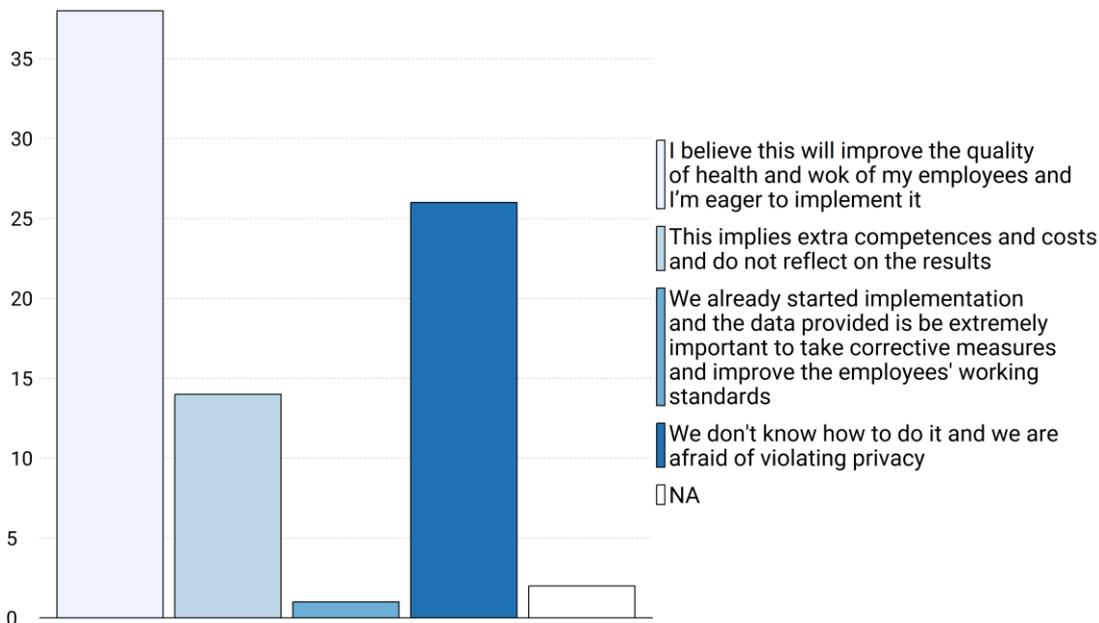
What is your opinion about end-user participation in the development of equipment and helping to develop interface?



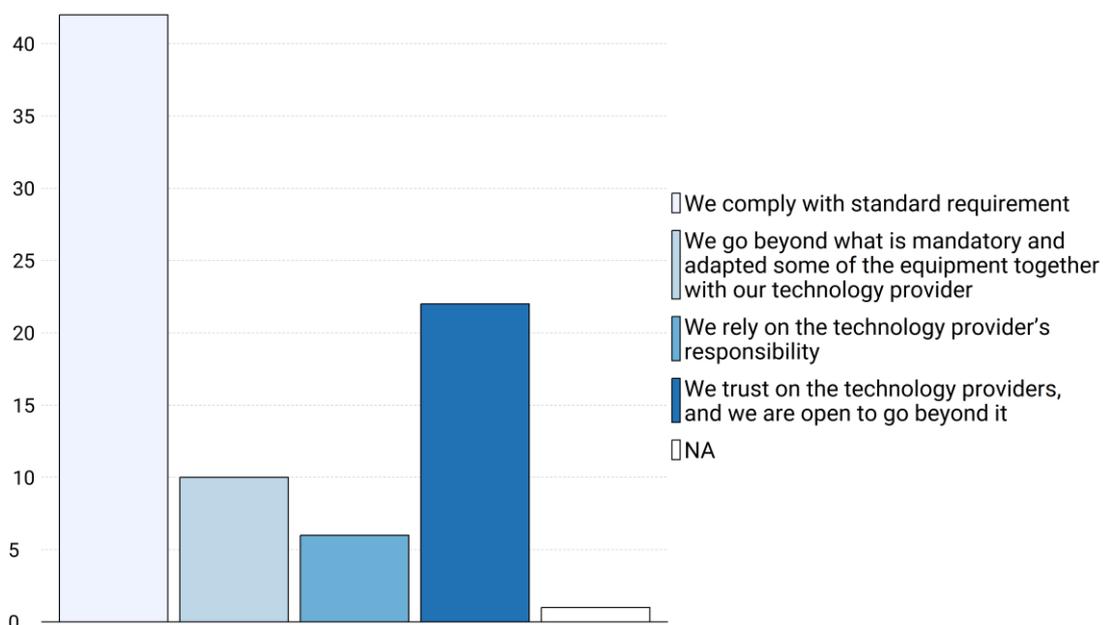
What steps should the industry take for a safer work environment?



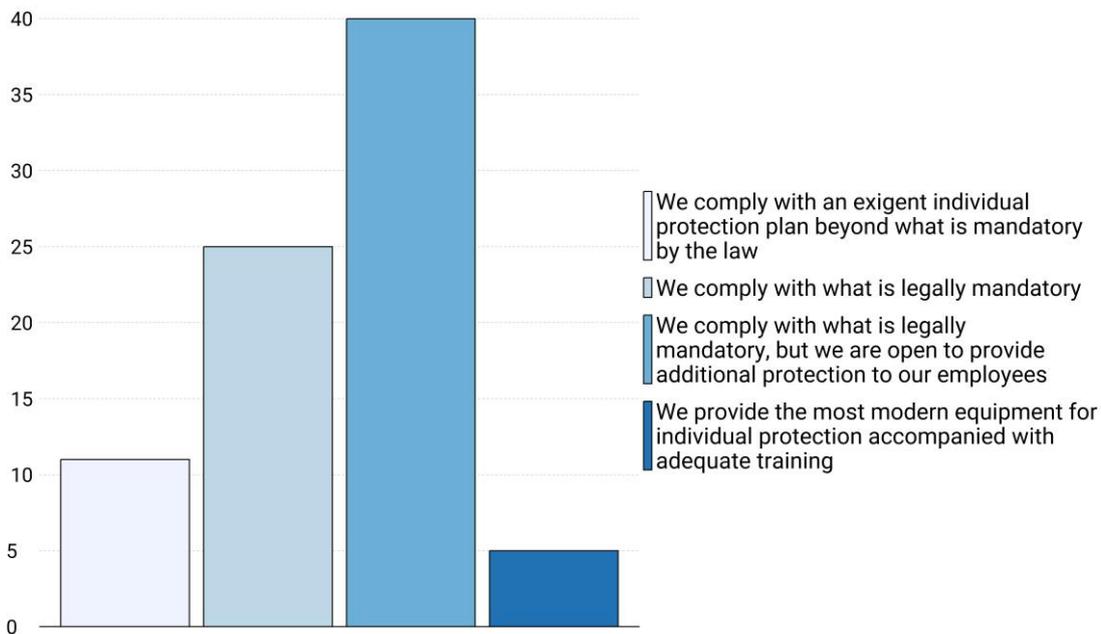
What are your thoughts about tracking workers health data? Embedded sensors in clothing and footwear? Sensors tracking for posture, physical strain and/or stress awareness?



To what extent is the equipment in the shopfloor ergonomic? How adapted is the equipment to the workers?



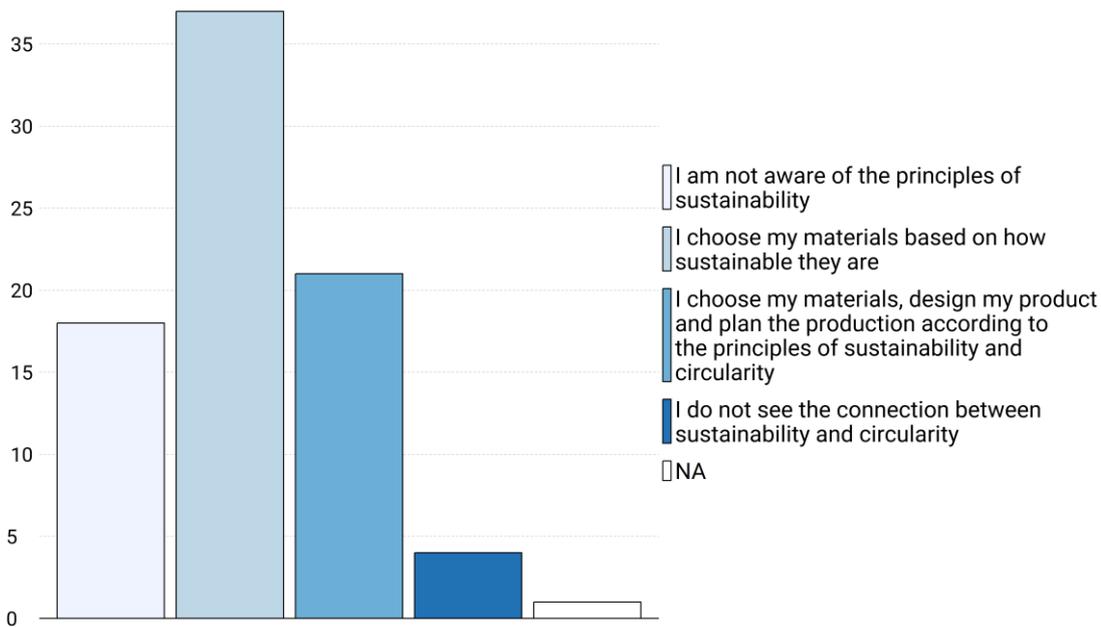
Outside what is enforced by law, should companies be responsible for health and safety of workers and supply equipment such as glasses (for computer monitor workers), ergonomic interface tools (such as mice and keyboards), or, in a more extreme way, exoskeletons for workers moving loads and/or posture corrections?



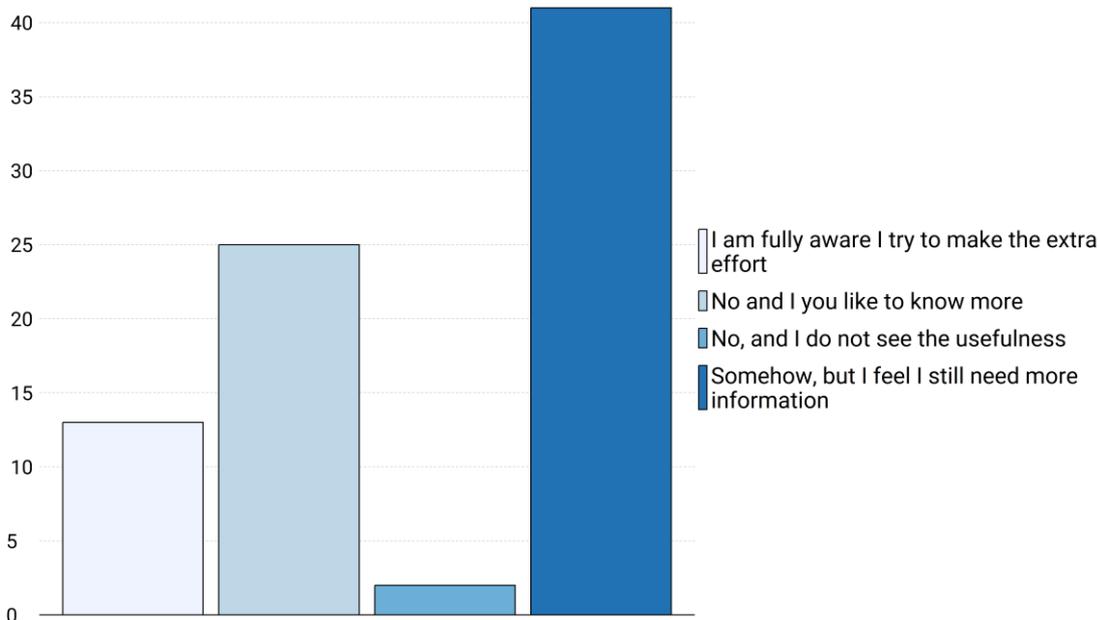
Sustainable

- Circular process that re-use, re-purpose and recycle natural resources, reduce waste and environmental impact.
- Reduce energy consumption and greenhouse emissions.

Do you design your product and manufacturing process according to circularity with sustainability in mind?



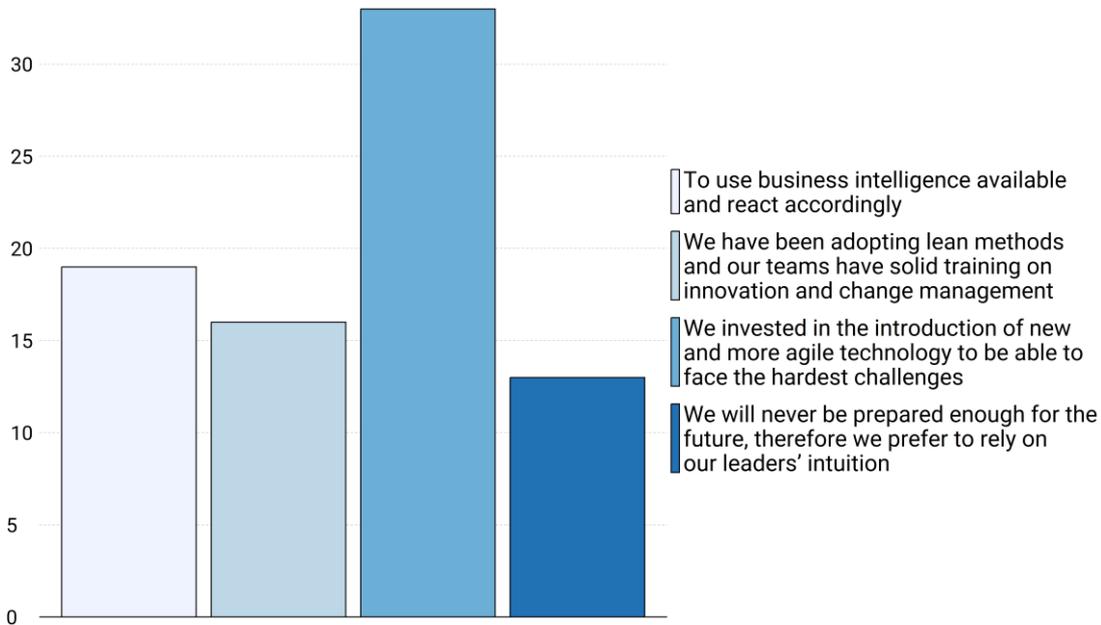
Do you feel you have enough training in sustainability and circularity to take the “extra step” over what is required by law?



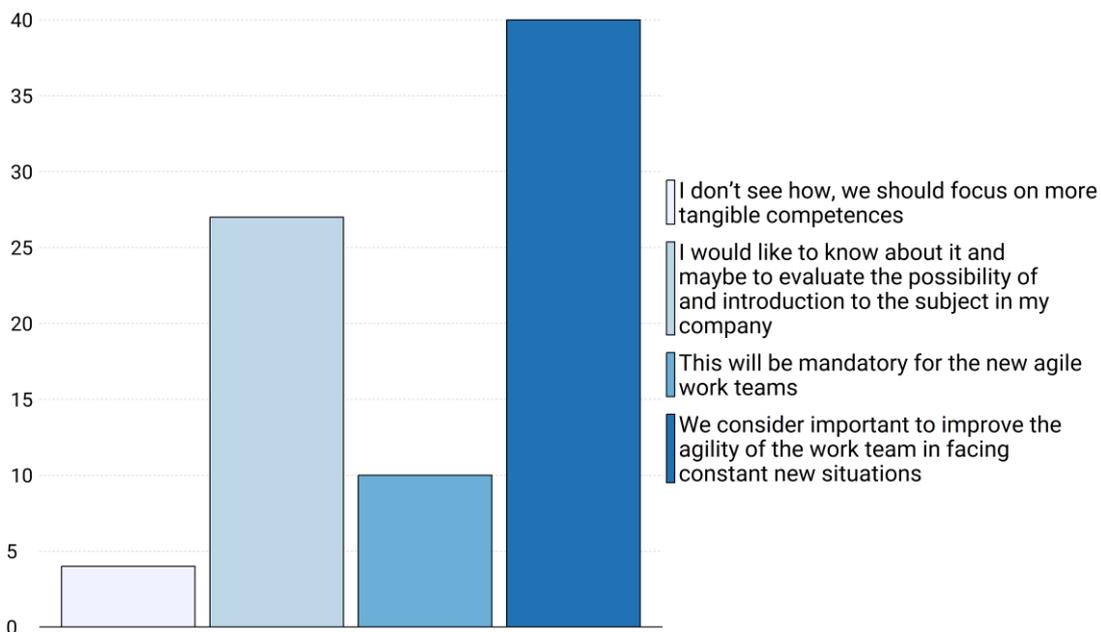
Resilience

- Higher degree of robustness in industrial production, arming it better against disruptions.
- Develop resilient strategic value chains, adaptable production capacity and flexible business processes.

How can the industry be more prepared to future challenges?



In what extent could companies benefit from change management training?



Benefits for worker and industry

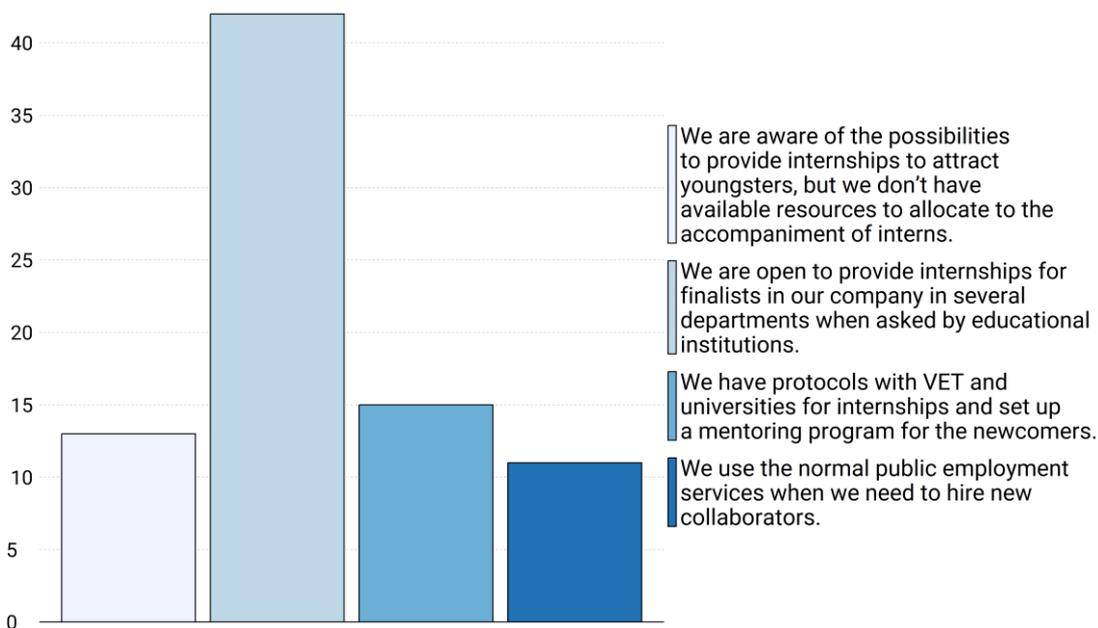
New role for the industry worker.

- From “cost” to “investment”
- Technology serves people
- Human-machine collaboration

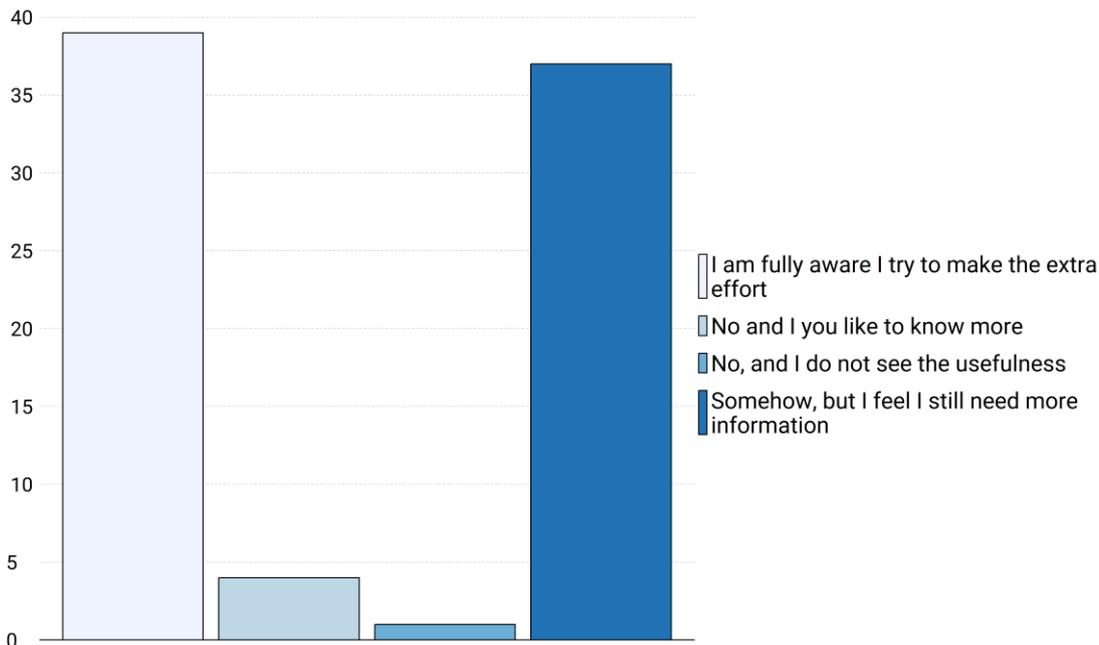
Safe and inclusive work environment.

Skills, up-skilling and re-skilling.

How can we attract and retain talents?

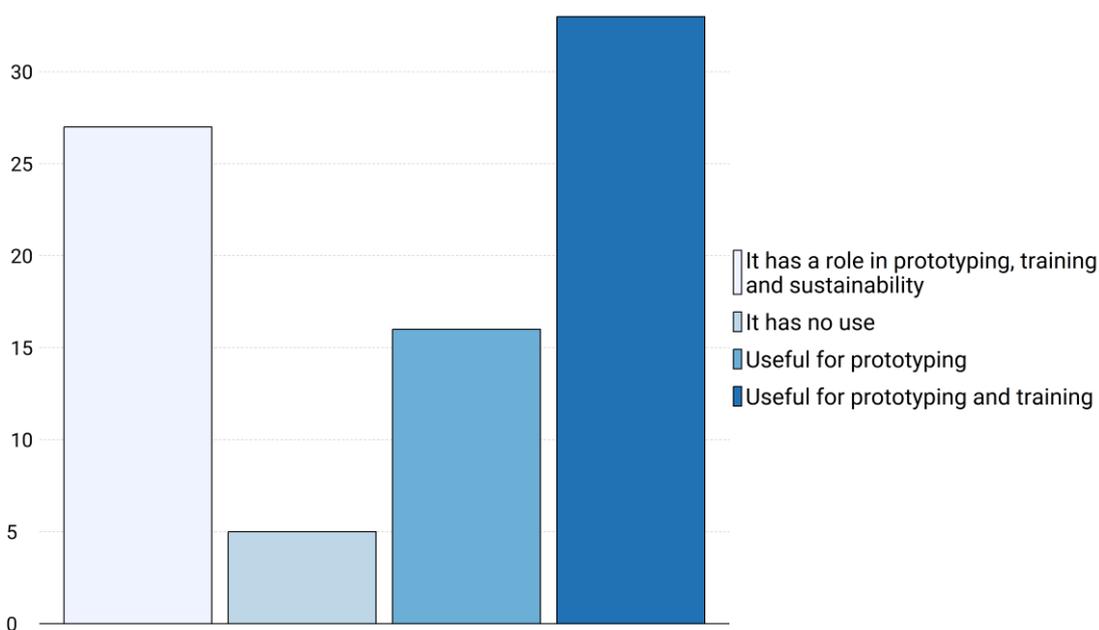


Do you know how much can better health and work environment result in better productivity and outputs?

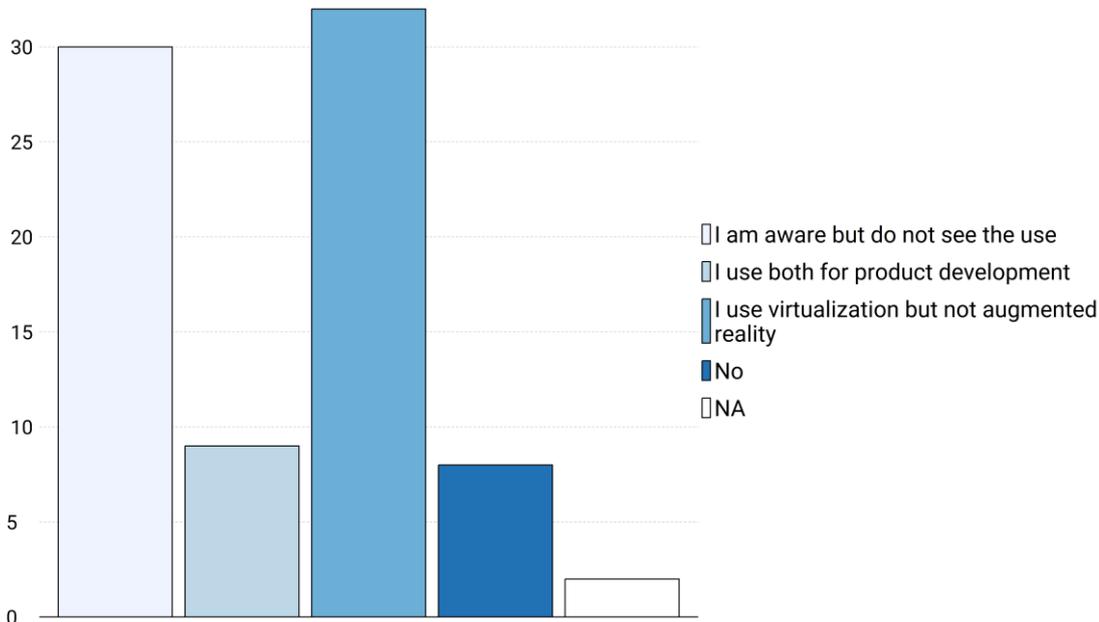


Enabling Technologies for i5.0

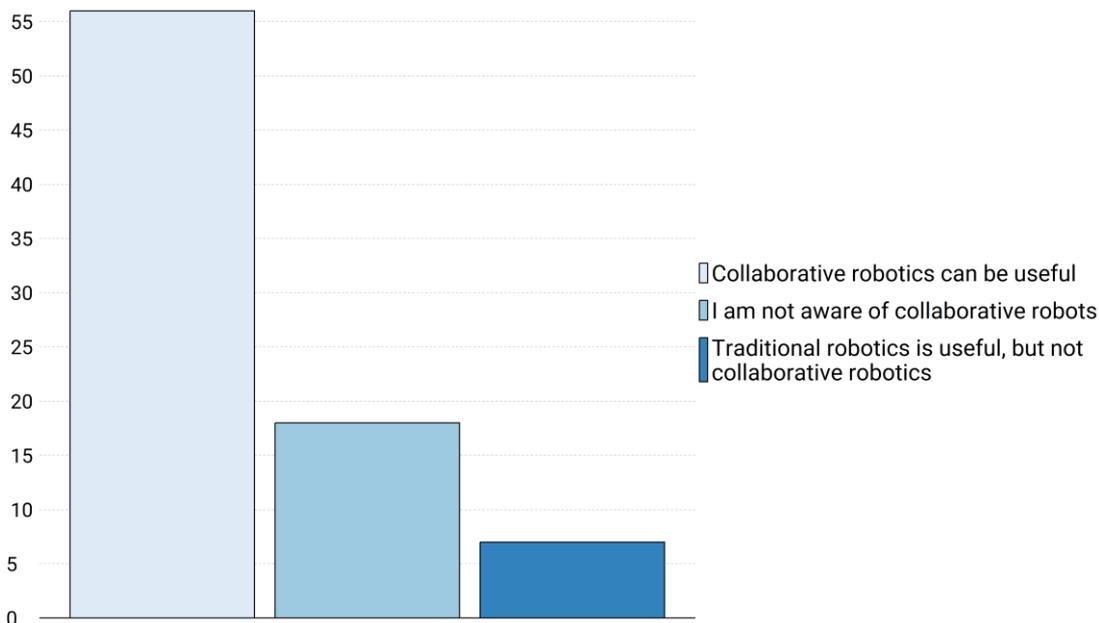
What is your view on augmented, virtual, and mixed reality? Prototyping? Training?



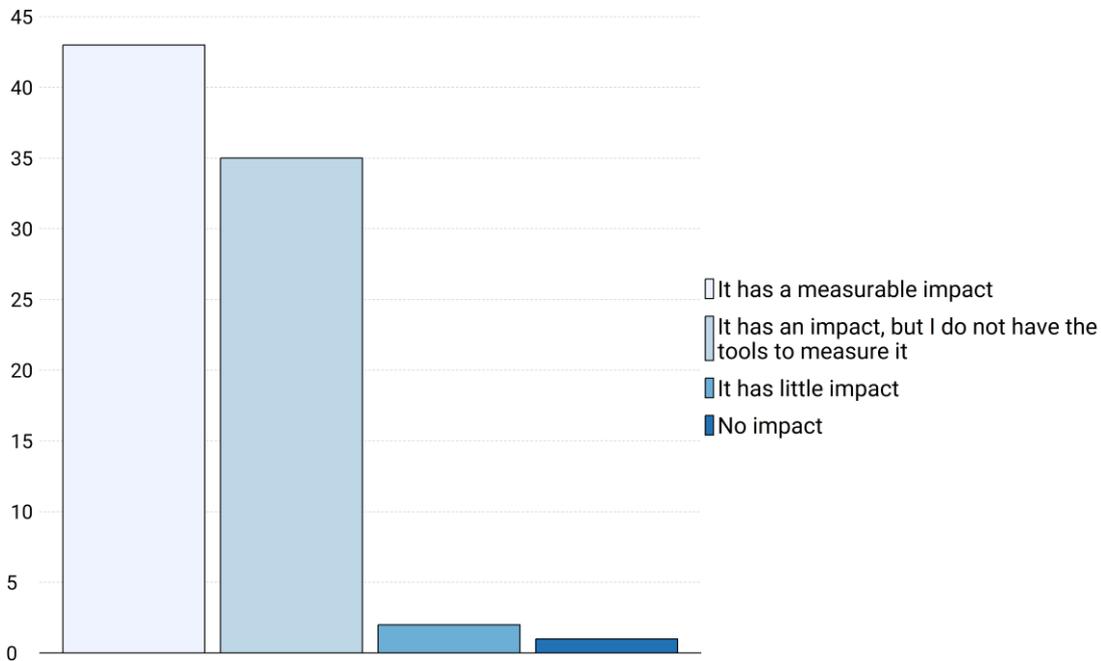
Are you aware that virtualization and augmented reality can be used for product development?



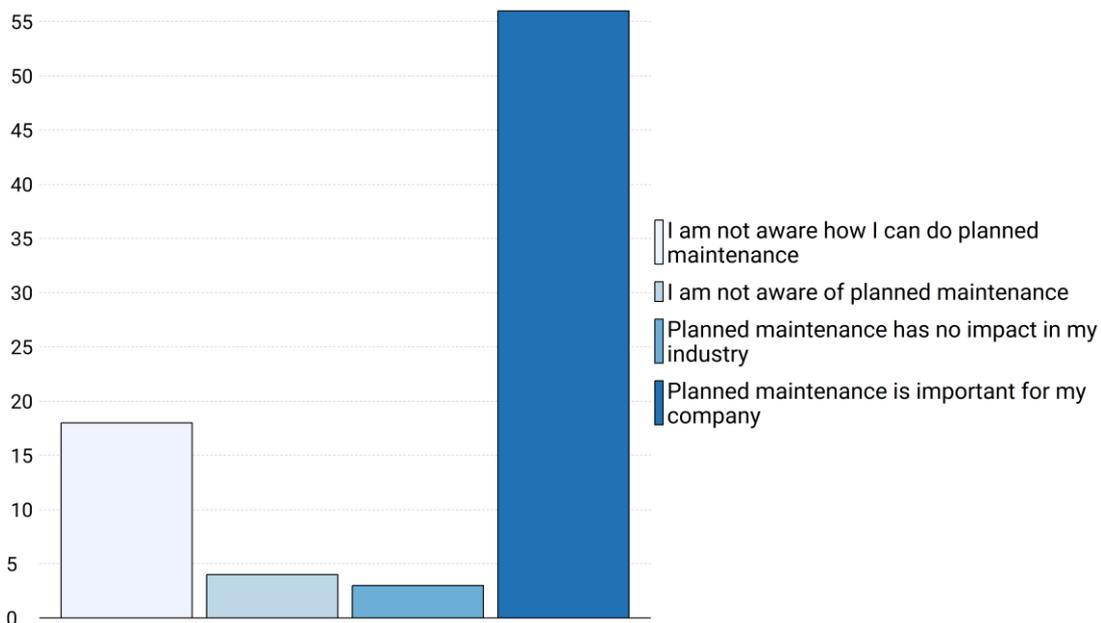
Collaborative robotics, do you see the industry adopting this type of robots in the future?



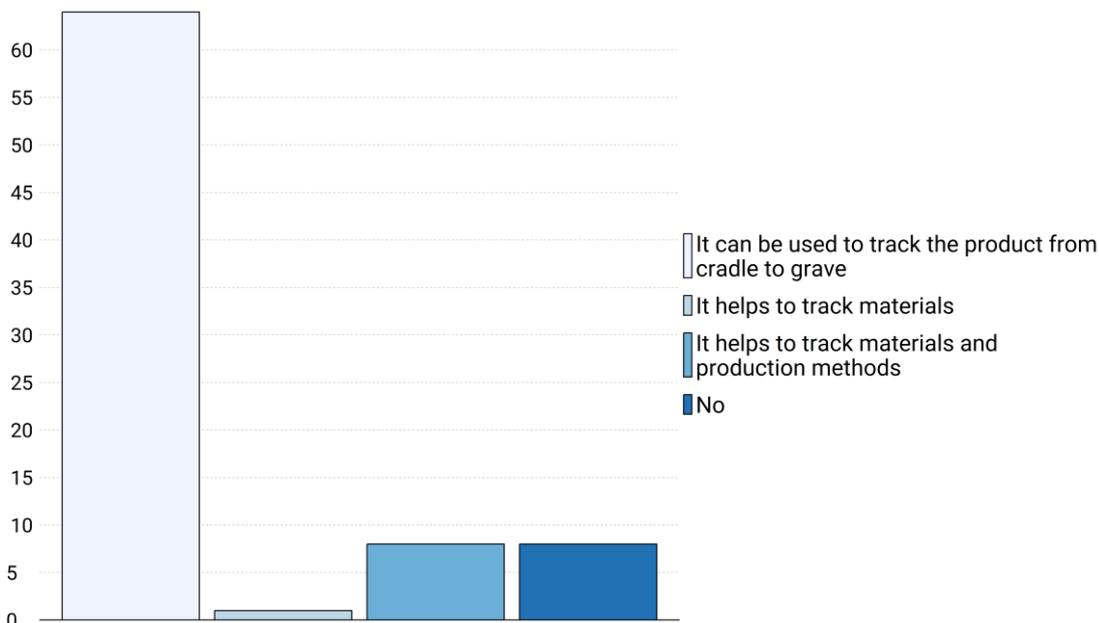
Are you aware of the impact of a stopped equipment in production?



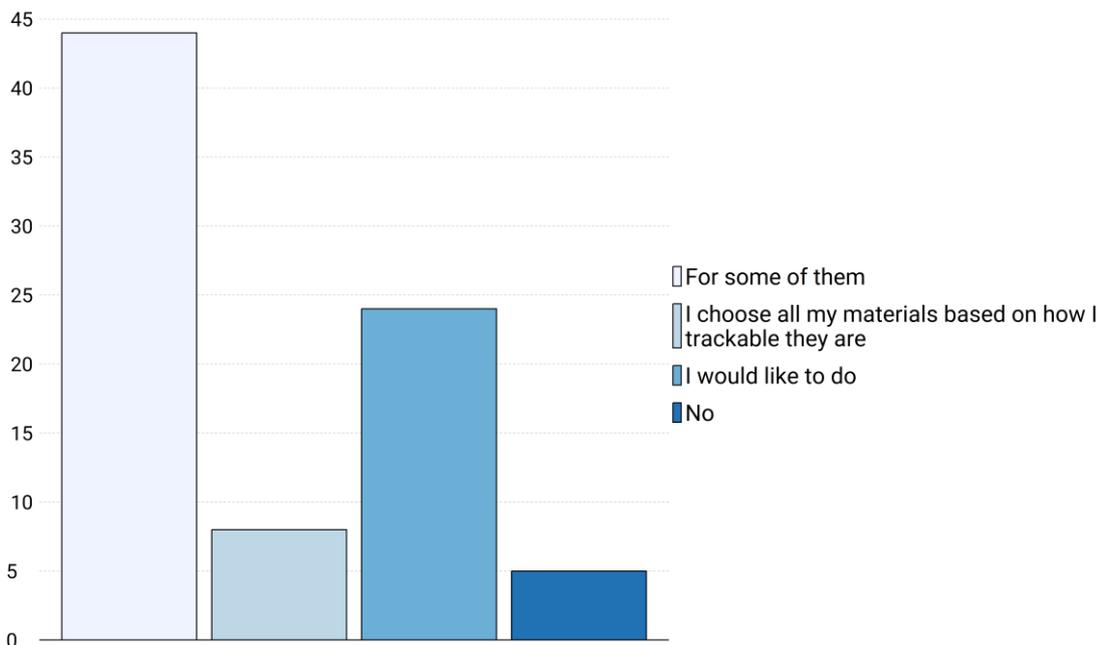
Should the industry implement tools for planned maintenance?



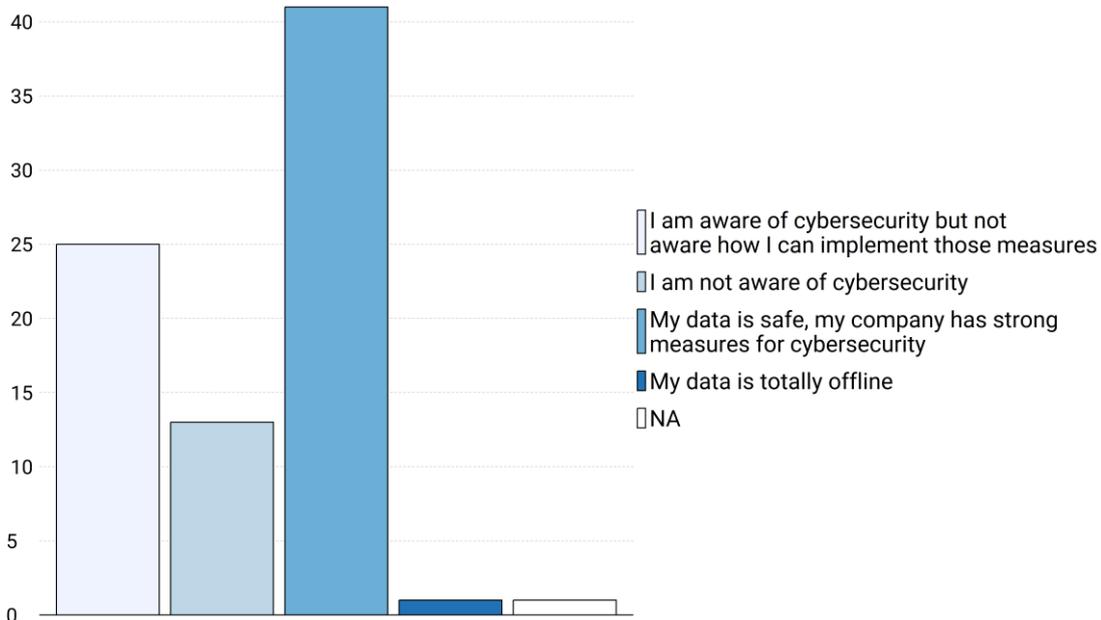
Do you know what traceability means?



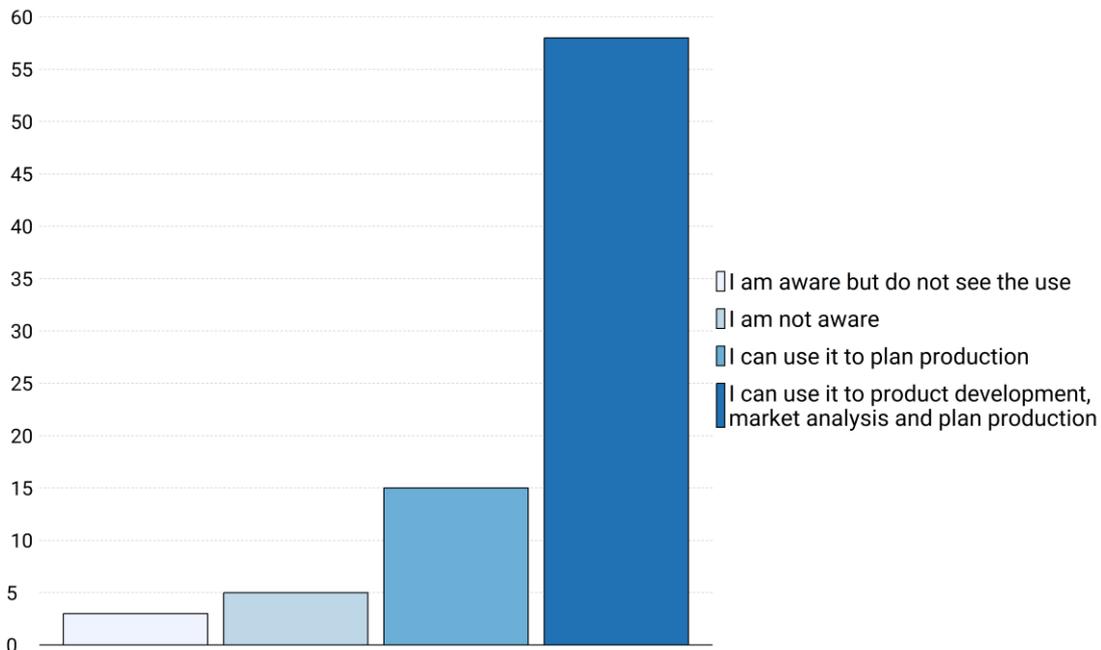
Is traceability an important subject when choosing materials for your products?



To what degree is your company data safe? Do you implement cybersecurity measures?

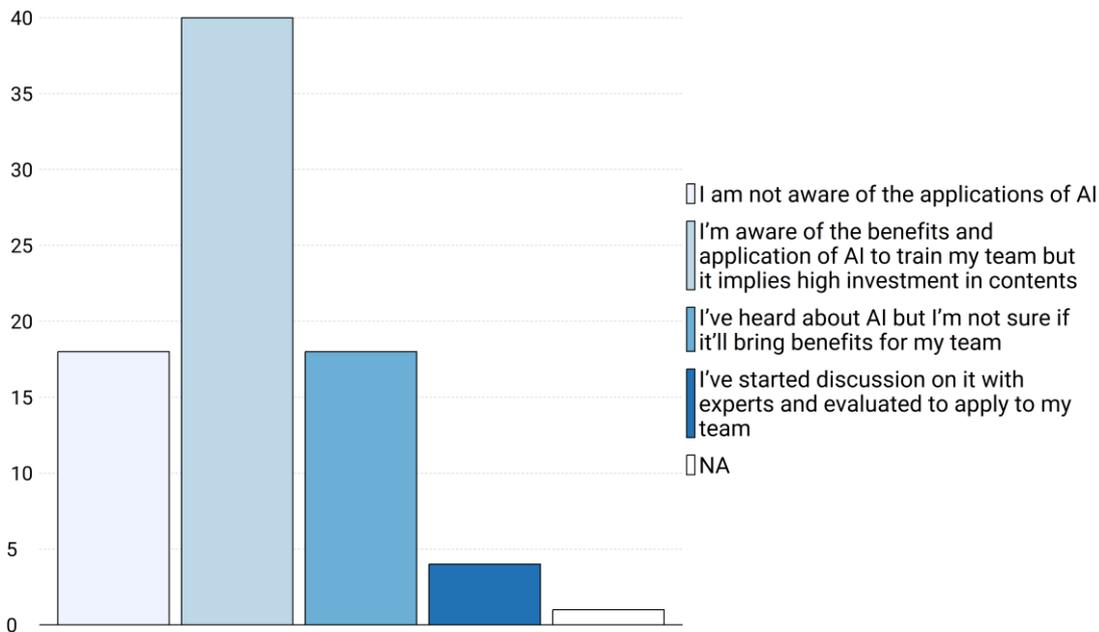


What are the potentialities of data collection and analysis?

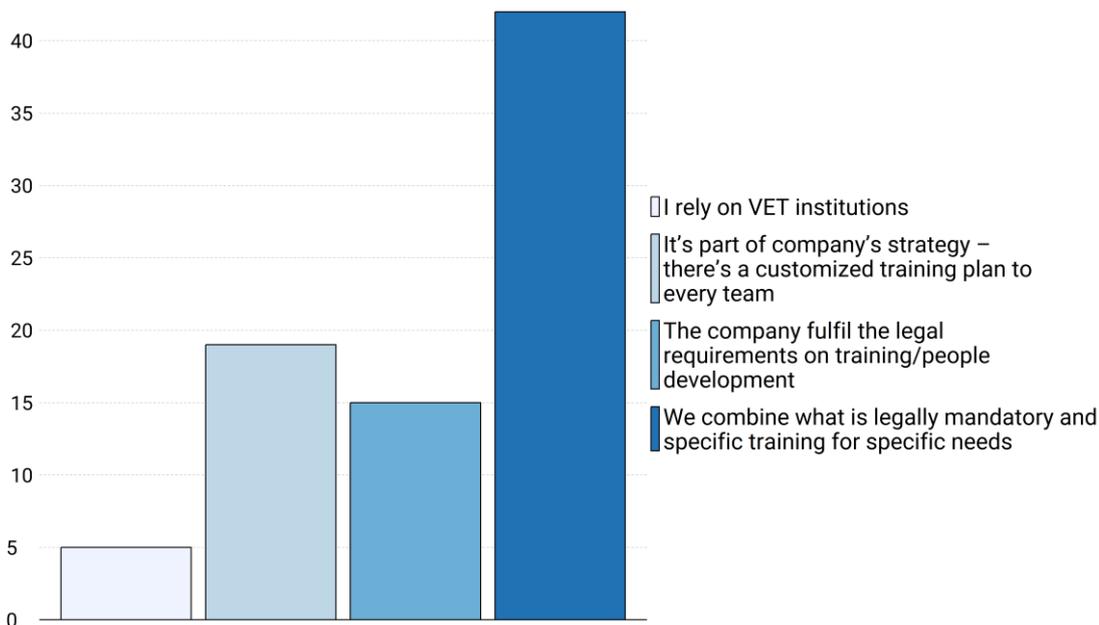


Training

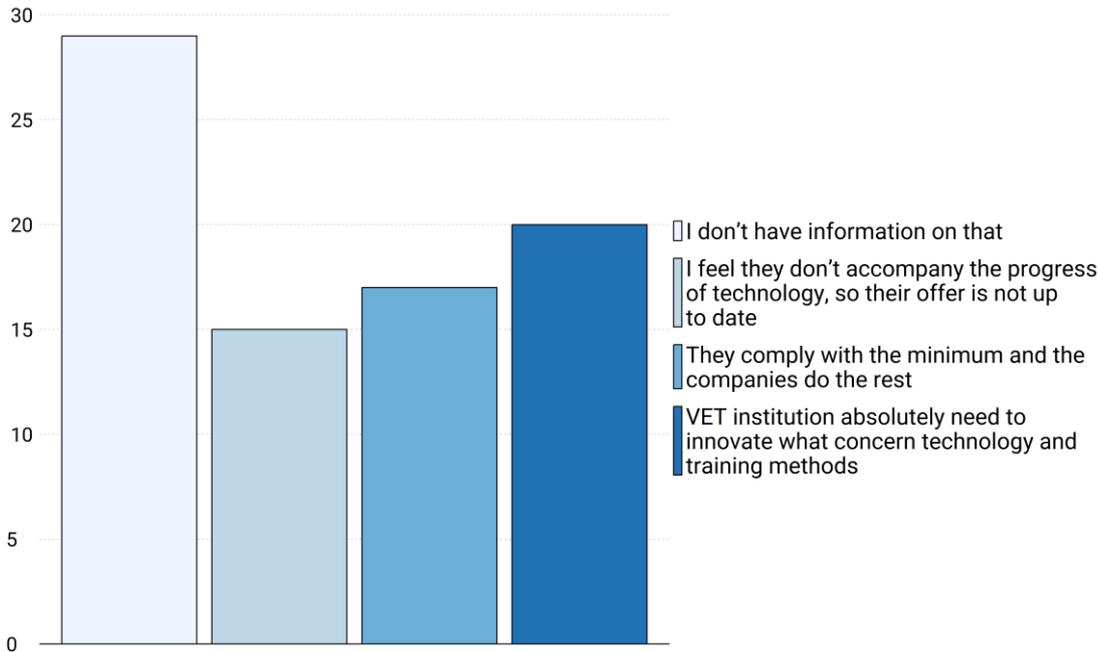
Artificial Intelligence in training, should the contents adapt to learners?



What is your view on skilling, up-skilling and re-skilling? Investing in people?



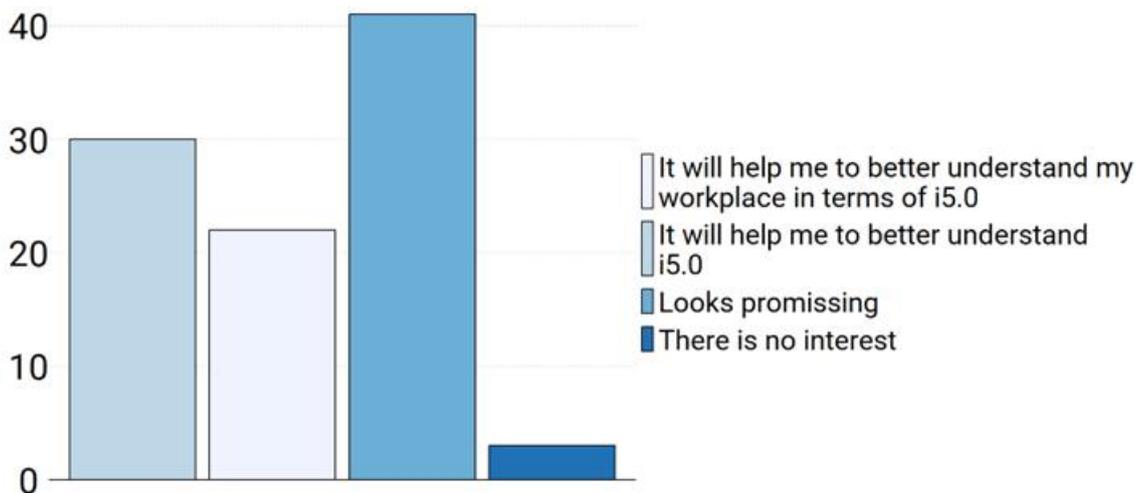
To what extent are training institutions up to date in training methods and subjects?



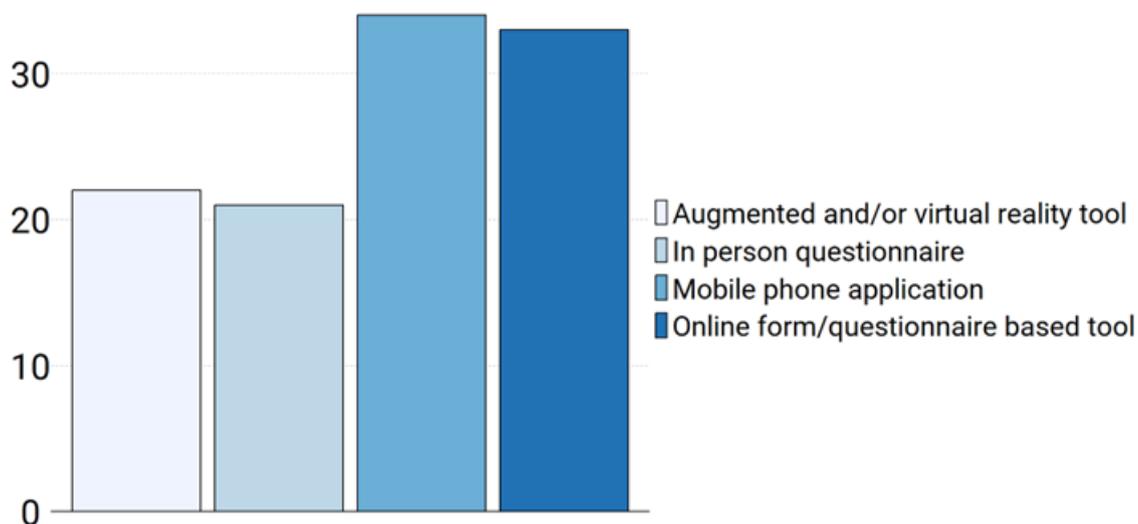
Assessment tool

The project is planning to develop a tool to understand how these concepts are implemented in the companies and to develop a training for each particular situation.

What do you think about the development of a tool that assesses the level of i5.0 implementation in your workplace?



What do you think would be the best way to evaluate it?



7. Conclusions.

From the literature review, questionnaire, and the focus-groups it was possible to draw some conclusions that will be influencing the project and the implementation of i5.0, particularly in the footwear industry.

- This next step needs to be centered on humans.
- Technology should be thought, planned, and conceived to better serve humans and industry.
- Training is crucial.
- Depending on the country, some companies are still on their way to i4.0, but i5.0 can be an opportunity for a better development.
- There is the need for change in the industrial organization, from management to the shop floor worker.
- Enabling technologies can be used as way to support:
 - Training needs.
 - Customer experience and mass customization.
 - Education and training.

The transition to i4.0 is still happening, however, i5.0 is not a replacement for i4.0. I5.0 will make this transition stronger and more future proof. New tools, frequently seen as the technology developments, are every time more capable to be a support for the humans and to bring efficiency for companies in every aspect of their operation.

From materials, to technology, from the product to the customer relationship, i5.0 represents a new step and new opportunities for the footwear sector. It needs to be supported on training, skilling and re-skilling of existing workers and management people, and will make the industry more attractive to the new generations.

Manufacturing will keep evolving in the concept of 5.0, with energy efficiency and lean concepts in mind. Automation and robotics will play a key role in this next step, but it will be with a human touch. At the same time, health and wellbeing, ergonomics and the digital anthropology are one of the main concerns of this new phase of the industry. Artificial intelligence will support design, prototyping, logistics, communication and, almost, every aspect of the industry, and needs to be based on data. Data needs to be gathered and analysed to better influence decision taking and innovation. Innovation will be based on multiple inputs in a truly cooperative work, leading to a greater degree of efficiency in the product development and creativity work.

I5.0 is an opportunity for a smart industry to appear in the European footwear sector. It will give tools for companies to be resilient, sustainable and, to be human centric. Taking care of the people that is the core of the industry is crucial for the health and wellbeing of the workers and, at the same time, for the survival of the company itself.

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